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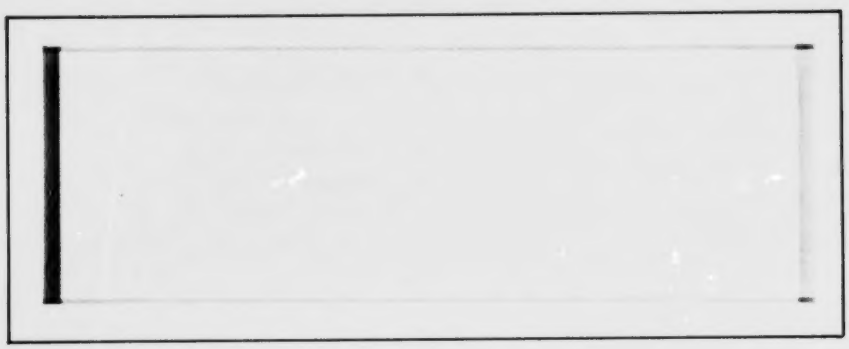

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COST COMPETITIVENESS OF APPLE PRODUCTION IN BRITISH COLUMBIA VERSUS WASHINGTON STATE

(Working Paper 18/86)

Mei Li Lee

Department of Agricultural Economics
University of British Columbia
Vancouver, B.C.

September 1986

This study was financially supported by an Extra-Mural Research Grant from Agriculture Canada.

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1. CHAPTER I

1.1 INTRODUCTION

Approximately 80 percent of all tree fruit production in the Okanagan Valley of British Columbia is apples; other tree fruits grown include cherries, apricots, peaches, prunes and pears. In recent years, unusual cold weather during critical growth periods has resulted in a reduction in the crop and fruit size. An example is the 1984 apple crop which consisted largely of small fruit. Low farm gate prices and high production costs have generated renewed concern in the tree fruit industry and its support industries regarding the future of British Columbia's tree fruit industry. B.C. apple orchardists claim that they are receiving five cents [1] a pound for apples that cost thirteen cents a pound to produce (Country Life, 1983). Fear has been expressed in the media that this 95 year old industry may have trouble reaching its 100th anniversary (Noonan, 1985).

As the single most important industry in the Okanagan Valley, the economic and social impacts would be enormous if the industry collapsed. It has been estimated that the average Okanagan orchardist circulates at least $50,000 from personal and operational spending each year through the local Valley economy (Noonan, 1983). Provincially, directly

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[1] Five cents is the market price prior to Farm Income Insurance payments.

and indirectly, the tree fruit industry injects about $750 million into the economy annually (Country Life, 1985). This industry constituted 11 percent ($97,844,000) of B.C.'s total Farm Cash Receipts in 1983 (B.C.M.A.F., 1984). It is ranked as the third most important sector within the whole B.C. agricultural industry, behind dairy products and cattle, respectively.

The future of the tree fruit industry lies in its ability to compete with other domestic and foreign producers, especially producers in Washington State. The current state of the B.C. tree fruit industry has been questioned with respect to a possible decline in relative economic efficiency (Kennedy, 1980). The purpose of this study is to examine the hypothesis that B.C.'s relative economic efficiency in producing apples is lower than that of Washington State.

1.2 THE PROBLEM

Due to the small size of B.C.'s apple industry relative to Washington State, apple producers in B.C. are considered to be price-takers in both the domestic and foreign markets. The per unit market price of B.C. apples is largely

determined by Washington State because of: 1) the size of the apple industry in Washington State, 2) the climatic conditions, and 3) the homogeneity property of apples by variety.

Washington State is ranked as the number one producer of apples in the United States. Its annual production averages approximately 30 percent of total U.S. production. Compared to B.C., Washington State's annual production averages (1966-1983) approximately six times greater than B.C. Climatically, Washington State tends to be warmer than the Okanagan Valley. The warmer climate is critical, especially immediately following the blossom period, since it frequently results in larger fruit and earlier harvests. The relatively homogeneous appearance of apples by variety causes consumers to make purchases based on appearance and taste rather than the origin of supply. Hence, it is important for B.C. to be competitive with Washington State, which is capable of supplying the same markets as B.C.

Recent developments in the apple industry suggest that B.C.'s ability to compete has declined. For example, data in Table 1 show B.C.'s growth rate in production to be much less than that of Washington State. This table shows that B.C.'s total production, in terms of percentages of Washington State's, averaged 21 percent during the period 1966 to 1970. This average dropped to 15 percent during 1979-83, a decrease of 28 percent. These statistics clearly imply that Washington State's rate of increase in apple

TABLE 1

TOTAL APPLE PRODUCTION IN B.C. COMPARED TO WASHINGTON STATE, CANADA, ND THE WORLD, 1966-1983.

	B.C.[a] (MIL. LB)	WASH. STATE[b] (MIL LB)	B.C./WASH. (%)	CANADA[a] (MIL LB)	B.C./CANADA (%)	WORLD[c] (MIL LB)	B.C./WORLD (%)
1966	341.8	1590.2	21.5	948.2	36.0	36660.0	0:93
1967	303.1	1240.0	24.4	983.4	30.8	40142.0	0.76
1968	232.7	1240.0	22.7	904.1	25.7	38320.7	0.61
1969	271.2	1675.0	16.0	979.0	27.7	44272.0	0.61
1970	291.2	1320.0	22.1	877.6	33.2	40338.3	0.72
1971	190.2	1201.0	15.8	833.5	22.8	40221.4	0.47
1972	242.9	1390.0	17.5	868.8	28.0	42788.0	0.57
1973	321.0	1860.0	17.3	826.9	38.8	49689.7	0.65
1974	240.3	1775.0	13.5	890.8	27.0	47231.1	0.51
1975	366.4	2200.0	16.7	985.6	37.2	51308.1	0.71
1976	380.8	2308.0	16.5	901.8	42.2	67391.4	0.57
1977	314.6	2083.0	15.1	921.7	34.1	64048.6	0.50
1978	331.7	2170.0	15.3	998.9	33.2	68972.4	0.48
1979	333.4	2619.0	12.7	959.0	34.8	80048.0	0.42
1980	463.5	3005.0	15.4	1218.5	38.0	77816.7	0.60
1981	445.5	2760.0	16.1	920.3	48.4	70372.6	0.63
1982	386.7	2615.0	14.8	1053.0	36.7		
1983	429.8	3000.0	14.3	1068.9	40.2		

SOURCES: [a] B.C.M.A.F., Production Of Tree Fruit Crops Together With An Estimate Of Farm Values.
Note: Does not include crabapples, 1979-81.
[b] United States Department Of Agriculture. Agricultural Statistics, Washington, D.C., U.S.Government Printing Office.
[c] FAO Production Yearbook. FAO, Rome.

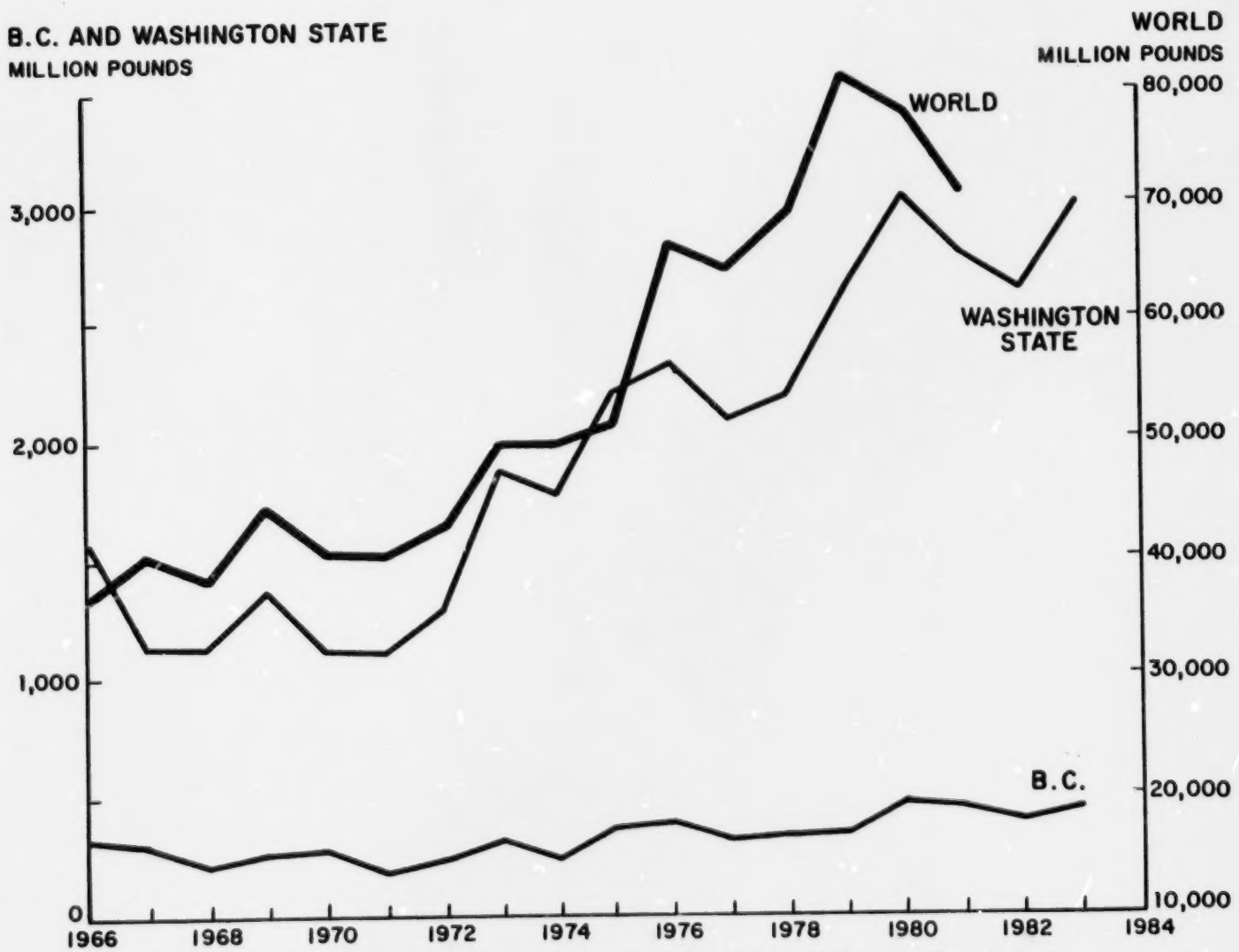

Figure 1: Total Apple Production In B.C., Washington State and The World

producton has been greater than B.C.'s. This implication is confirmed by examining B.C. and Washington State's growth in production over the period 1966 to 1982. Based on five year averages (1966-70 and 1979-83), B.C.'s total apple producton showed an increase of 43 percent while Washington State revealed an impressive 98 percent increase. In Canada, B.C.'s total apple production as a percentage of all Canadian production has increased 11 percent during the same period. However, compared to the World, the percentage of B.C.'s total production has declined by 27.5 percent.

Annual total apple production in B.C., Washington State and the World are graphed in Figure 1. Compared to Washington State and the World, B.C.'s increase in total production began falling behind during the mid-seventies. The tremendous increase in production experienced by both Washington State and the World during the years 1978-80 did not occur in B.C. In contrast to the erractic fluctuations shown by Washington State and the World in the late seventies, changes in B.C.'s annual production have been relatively small. At a time when Washington State and the World are increasing their production at an accelerated rate, B.C.'s relatively stable production growth becomes a matter for concern.

Stable production growth is a concern as the total Canadian consumption of fresh apples is increasing at a higher rate, as shown in Table 2. Since 1960, total Canadian consumption of fresh apples has risen at an increasing rate.

TABLE 2

CONSUMPTION, EXPORTS AND IMPORTS OF B.C. AND CANADIAN FRESH APPLES, 1960-1983

	TOTAL CANADIAN CONSUMPTION[a] (MIL LB)	EXPORTS FROM B.C. CUSTOMS[b] (MIL LB)	EXPORTS FROM CANADA[a] (MIL LB)	IMPORTS TO B.C. CUSTOMS[b] (MIL LB)	IMPORTS TO CANADA[a] (MIL LB)
1960	344		110		52
1961	347		100		58
1962	535		124		50
1963	574		146		37
1964	542		145		62
1965	533		129		64
1966	473		118		55
1967	434		155		46
1968	557		157		71
1969	580		130		62
1970	538	38.4	104	24.8	92
1971	566	34.4	102	23.2	82
1972	507	26.4	99	26.6	88
1973	541	60.0	118	25.2	94
1974	663	50.6	78	29.6	136
1975	690	49.0	86	35.6	148
1976	683	69.6	99	25.8	176
1977	574	73.8	106	30.0	147
1978	622	83.8	124	36.8	164
1979	619	81.0	121	44.0	212
1980	572	85.4	133	53.0	173
1981	696	112.2	166	44.4	240
1982	651	126.8	155	61.2	236
1983		136.6		51.0	

SOURCES:
[a] Statistics Canada, Supply and Disposition of Selected Food Groups.
[b] B.C. Ministry of Industry and Small Business Development, B.C. External Trade Report, 1970-83.

From an annual consumption of 344 million pounds in 1960, total consumption of fresh apples has reached 651 million pounds in 1982, an increase of 89 percent.

Exports of fresh apples from Canada averaged 131 million pounds during the sixties. In the seventies, average exports of fresh apples from Canada declined to 103 million pounds. The average exports of fresh apples from Canada increased to 151 million pounds in the early eighties, 1980-82. This average is 15 and 46 percent higher than the averages of the sixties and seventies, respectively.

Data on exports of fresh apples from B.C. customs[2] suggest that an increasing amount of fresh apples exported from Canada are being exported through B.C. From an average of 33 million pounds (1970-73), exports of fresh apples from B.C. have increased to an average of 125 million pounds (1981-83), an increase of almost 280 percent.

Canadian imports of fresh apples have reached an average of 216 million pounds in recent years, 1980-1982. The averages imported in the early seventies (1970-72) and sixties (1960-62) are 87 and 53 million pounds, respectively. In just over two decades, imports of fresh apples have increased 307 percent. Similar to exports, imports of fresh apples through B.C. customs[3] have been increasing rapidly over the period 1970-82. The import and consumption data on fresh apples suggest that the demand for

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[2] The fresh apples exported from B.C. need not originate in B.C.

[3] Not all fresh apples imported through B.C. customs are consumed in B.C.

TABLE 3

AVERAGE PRODUCER RETURNS FOR FRESH AND PROCESSED APPLES: B.C. VS. WASHINGTON STATE, 1959-83

	AVE. PRICE TO WASH. STATE PRODUCERS[a] (US CENTS/LB)	AVE PRICE TO WASH. STATE PRODUCERS[1] (CAN CENTS/LB)	AVE. PRICE TO B.C. PRODUCERS[2,b] (CAN CENTS/LB)	REAL AVE PRICE TO B.C. PRODUCERS[3] (CAN CENTS/LB)	REAL AVE PRICE TO WASH. STATE PRODUCERS[4] (US CENTS/LB)
1959	4.48	4.30	3.30	10.60	13.90
1960	5.54	5.37	3.90	12.40	17.00
1961	5.61	5.68	4.80	15.10	17.06
1962	4.90	5.24	4.00	12.50	14.70
1963	3.54	3.82	3.20	9.80	10.50
1964	4.69	5.06	3.60	10.80	13.70
1965	5.62	6.06	4.60	13.50	16.20
1966	4.95	5.33	3.90	11.10	13.86
1967	7.24	7.81	5.30	14.50	19.72
1968	7.93	8.54	6.60	17.40	20.73
1969	2.93	3.06	3.50	8.80	7.27
1970	5.07	5.12	4.30	10.50	11.87
1971	6.20	6.14	4.60	10.90	13.92
1972	8.21	8.13	4.80	10.90	17.85
1973	8.40	8.40	6.10	12.80	17.20
1974	9.30	9.10	6.80	12.90	17.14
1975	6.10	6.20	3.50	6.00	10.30
1976	9.20	9.07	5.40	8.10	14.70
1977	13.00	13.78	8.80	13.00	19.50
1978	12.60	14.15	10.00	13.50	17.56
1979	12.70	14.56	10.30	12.80	15.90
1980	8.20	9.39	6.10	6.90	9.05
1981	10.90	12.71	8.86	8.86	10.90
1982	9.50	11.30	6.22	5.30	8.93
1983	11.40	13.50	7.64	6.33	10.30

1 Average annual exchange rates are used.
2 Excludes payment from support programs.
3 Deflated by the annual Canadian CPI for all commodities (1981=100).
4 Deflated by the U.S. CPI for all commodities (1981=100).

SOURCES:
a Washington Crop and Livestock Reporting Service, Washington Agricultural Statistics.
b Agriculture Canada, Farmbank data.
B.C.M.A.F., Production Of Tree Fruit Crops Together With An Estimate Of Farm Values.
Note: Net of subsidy payments.

fresh apples has been rising rapidly and that apple producers have not increased production to the level of rising demand. Although total Canadian exports of fresh apples have been rising, the increase is not enough to explain the large increase in imports of fresh apples.

Why has production growth been retarded in B.C.? Growth in production can be generated either by expanding existing orchards, establishing new orchards, or replacing old, less productive trees with young, high yielding trees. As noted by Cahill, orchard replacement, establishment, and expansion are largely motivated by profits or net market returns (total revenues minus total costs). Assuming rational entrepreneurs, expansion will be less likely to occur if profit levels are low. That Washington State and the World are expanding suggests that net market returns to producers outside B.C. must be greater than those received by B.C. orchardists.

The average market prices received by B.C. and Washington State apple producers are shown in Table 3. For comparison purposes, average market prices received by producers in Washington State are also shown in Canadian dollars. Table 3 reveals that market prices received by Washington State producers have been and continue to be above those received by producers in B.C. During the last decade, the difference between B.C. and Washington State's average market price has increased. For example, the average price difference between the two regions during the period

1971-75 is 2.4 cents per pound, but the same price differential is almost double during the period 1976-82. In the late sixties, the same price differential is 1.76 cents per pound. In real terms, market prices have remained higher in Washington State.

In addition to a decline in market prices, B.C. producers are faced with increasing production costs. The disparity between market prices and production costs is reflected in the net Farm Income Insurance (FII) payments. The provincial Farm Income Insurance (FII) program provides a guarantee that the producers will, at the minimum, receive a price equal to that of production costs. The cost of producing a pound of apples is negotiated between producers and the B.C. Ministry of Agriculture and Food (B.C.M.A.F.) representatives. [4] Under this program payments are made to producers when the price received by producers is lower than the negotiated production costs. The price received by producers is estimated as the market return plus payments from the federal Agricultural Stabilization Act (ASA). Both programs are discussed in detail in Chapter II. Since its existence in 1973, the FII program has been making payments to apple producers almost annually. The net per pound FII and ASA payments over the period 1973 to 1984 are shown in Table 4. The FII payments have averaged 1.9 cents per pound over the period 1973-76 and 3.1 cents per pound during the period 1980-83. Recent support payments have averaged 60

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[4]The FII production model does not include any fixed cost associated with owning the capital assets.

TABLE 4

NET FARM INCOME INSURANCE (FII) AND AGRICULTURAL STABILIZATION (ASA) PAYMENTS TO B.C APPLE PRODUCERS, 1973-1984

	AVE. FII PAYMENTS[a] (CENTS PER LB)	AVE. ASA PAYMENTS[b] (CENTS PER LB)
1973	1.27	
1974	1.27	
1975	2.94	2.10
1976	2.10	
1977	0.15	
1978	0.19	
1979		
1980	4.35	1.77
1981	2.31	
1982	3.04	2.10
1983	2.50	
1984	1.00	

NOTE: The 1984 FII payment represents an initial advancement only.

SOURCES:
[a] Crop Insurance Statistics, Crop Insurance Branch, B.C.M.A.F.
[b] Stella Murjesco, Agricultural Advisor, Agricultural Stabilization Board, Agriculture Canada, Ottawa.

percent higher than those of the early seventies.

Concern over the disparity between market returns and production costs in recent years is further reflected by the ASA payments. Under this program, two payments have already been made to apple producers in the past four years. In contrast, only one payment was made during the seventies. Support payments from FII and ASA programs indicate that both levels of government view market returns to B.C. producers as being low relative to their costs of production.

Are net market returns in B.C. as low as the data imply? Recent behaviour of the apple producers suggests that the profit levels are below an acceptable standard. A number of articles with quotes or statements made by members of the tree fruit industry have appeared in various newspapers, especially Country Life, in recent years. The most frequent recurring theme has identified the decline in net market returns. The measures that orchardists have employed to demonstrate their dissatisfaction can be traced through these articles. For example, in October 1983, a demonstration was organized by tree fruit producers in the Okanagan Valley to protest low market returns on fruits. Later, in November, representatives of producer organizations met with the then Federal Minister of Agriculture to discuss the possibility of imposing a tariff on fruit entering B.C., and potential expansion of the federal Farm Credit Corporation to assist producers who

faced refinancing of their debt loads (Noonan, 1983). All of these measures strongly indicate low net market returns to orchardists as an issue rising in importance.

Why is there a disparity between market prices and production costs? As suggested previously, a decline in relative economic efficiency could be the essence of B.C.'s problem. An indicator of economic efficiency is market returns. Given the structure of B.C's industry, whereby prices received by producers are net of processing and marketing costs, market returns provide an indication of the efficiency of the processing, distributing, and marketing sectors through their abilities to obtain a higher price or produce/market at a lower price. At the production level, economic efficiency is incorporated by examining net market returns from employing a given value of inputs.

The suggested decline in economic efficiency can occur at the farm, processing, distributing, and/or marketing level within the industry. Wherever it occurs, it ultimately translates into lower profit levels for producers. The fact that profit levels for B.C. producers relative to Washington State appear to be falling does not necessarily imply that efficiency is falling at the farm level in B.C. However, it may be and if B.C. is to improve its relative efficiency at the farm level an understanding of relative costs is required. This study attempts to provide this understanding.

1.3 OBJECTIVE

The main objective of this study is two-fold:
1) to determine the average cost of producing Red Delicious apples in both B.C. and Washington State; and
2) to compare the average cost of producing apples in B.C. with that of Washington State.
To achieve these goals, a cost of production model is constructed to determine the average cost of producing apples in B.C. and Washington State. Results obtained are compared and discussed. Policy implications arising from the results are also examined.

1.4 ORGANIZATION OF REPORT

Chapter II describes the apple industries in B.C. and Washington State. It includes a discussion of the geographic location, varieties grown, and characteristics of the orchards in the two regions. Government and tax programs, as they relate to orchards, in B.C and Washington State are also examined.

Chapter III consists of two sections. Section one focuses on existing cost of production studies in B.C. and Washington State. It includes a discussion of theoretical issues and problems surrounding cost of production models. Section two presents the methodology that will be applied in this study to calculate the cost of producing apples. It concentrates on the background assumptions of the model, methods used to derive operating and capital costs, and data sets.

Chapter IV presents an analysis of the results obtained from the model. The analysis is presented in three separate sections. The first section focuses on results obtained from production schedules. Section two compares the per acre and per pound costs estimated for B. C. and Washington State. It identifies the area(s) in which B.C.'s costs are higher or lower than Washington State's. Results obtained from various sensitivity analyses are examined in section three.

The conclusions of the study are discussed in Chapter V. This chapter includes a discussion on the limitations of this study, policy implications and areas of possible future studies.

2. CHAPTER II

2.1 THE APPLE INDUSTRIES IN B.C. AND WASHINGTON STATE.

Due to climatic factors, approximately 90 percent of B.C.'s apples are grown in the Okanagan Valley. Geographically, this includes the area stretching from Vernon south through Kelowna, Peachland, Summerland, Keremeos, Oliver and Osoyoos. On average, orchards in the northern regions, such as Vernon and Kelowna, are relatively larger than those in the southern regions, Oliver and Osoyoos. The difference is partly attributed to the availability of arable land.

In Washington State, apple production is concentrated mainly in three regions. Region one starts directly south of the Canada-US border crossing near Osoyoos. This region includes Oroville, Omak, Okanogan, Brewster, Chelan and Wenatchee. Yakima and its surrounding area constitutes the second orchard region. Region three, located directly east of the Columbia River, is commonly referred to as the Columbia Basin. The region starts at Grand Coulee and stretches south to include Ephrata, Quincy, Mattawa, Othello and Pasco. The average orchard size in region one is similar to that of the Okanagan Valley in B.C., especially orchards in Oroville, Okanogan, and Chelan. The availability of arable land is also a limiting factor for this region. On

average, partly as a consequence of more arable land, orchard blocks in the Yakima area are larger than those in region one. The largest average orchard blocks are located in the Columbia Basin where the supply of arable land is abundant.

This study focuses on representative orchards, as defined in Chapter III, located in the Okanagan Valley in B.C. and the Columbia Basin in Washington State. As noted previously, the majority of B.C.'s apples are produced in the Okanagan Valley; hence, it is appropriate that the representative orchard should be located in this Valley. For Washington State, the Columbia Basin is chosen for two reasons: 1) the availability of data, and 2) it is the growth area, both presently and for the future, for apple production in Washington State. All existing establishment and production cost studies on apple orchards compiled by researchers in Washington State employ a representative orchard from the Columbia Basin (Hinman, Hunter, and Tukey, 1981, 1982, 1985). Since production data for Washington State are largely limited to existing orchard studies, the location of this study's representative orchard is thus determined.

In Washington State, recent plantings have occurred predominately in the Columbia Basin where a large supply of water has been made available at relatively low cost to producers. It has been estimated that, by the early 1990s, Washington State will be capable of producing 4,654 million

pounds of apples annually (O'Rourke). This is a 36 percent increase over the 1983 production. Such a large increase in apple production is bound to have an effect on B.C.'s apple industry. Hence, it would be useful to compare the current efficiency of B.C.'s apple production with that of the Columbia Basin where expansion has occurred very rapidly over the last ten years.

The cost estimated for the Columbia Basin can be extended to the Yakima region with few adjustments.[5] The climate, input prices and management practices in the Yakima area are similar to those of the Columbia Basin. More cost adjustments are required if the model is used to reflect production cost in region 1. For example, due to the smaller orchard size, the set of machinery may require an adjustment, i.e. the size of the tractor.

2.2 VARIETIES GROWN

'Apple' is a term that makes no distinction among the varieties available to producers and consumers. However, since prices vary by variety, it is useful to examine the mix of varieties grown in both B.C. and Washington State, as

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[5] Horticulturists from Washington State.

in Table 5. This table indicates that, as a percentage of all apples produced in its respective area, Red Delicious is the dominant variety grown in both B.C. and Washington State. On average, this variety constitutes 41 and 63 percent of B.C. and Washington State's total apple production, respectively, over the period 1972-83. In B.C., McIntosh and Spartan rank as the second and third varieties produced. In contrast, these varieties do not appear to be popular with growers in Washington State, where Golden Delicious and Winesap are ranked two and three, respectively. Recent estimates of new Washington plantings, mainly in the Columbia Basin, suggest that Red Delicious will remain the primary variety in the near future (Swales). However, it has been speculated that Granny Smith may replace Golden Delicious in importance. [6] This is primarily due to higher market returns for Granny Smith. Granny Smith can be grown in the southern Okanagan of B.C. but is not expected to gain importance due to climatic restrictions.

Since Red Delicious is the dominant variety produced in B.C. and Washington State, this study will focus on this variety. Thus, the term 'apple' will be used to refer to the Red Delicious variety. All costs, yields and returns discussed in the remainder of the study are those associated with this particular variety.

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[6]Conversation with field representatives in Washington State.

TABLE 5

PROPORTIONS OF VARIOUS VARIETIES OF APPLES PRODUCED IN B.C. AND WASHINGTON STATE, 1972-1981
(PERCENT OF TOTAL PRODUCTION)

		RED DELICIOUS	GOLDEN DELICIOUS	ROME BEAUTY	WINESAP	McINTOSH	SPARTAN	OTHERS[b]
1972	B.C.	34.5	9.6	0.6	5.5	32.0	14.6	3.2
	WASH.	57.0	31.0	2.5	8.0	a	a	1.5
1973	B.C.	39.8	9.6	0.8	4.3	28.4	14.5	2.6
	WASH.	64.2	24.6	2.4	6.0			2.8
1974	B.C.	40.1	13.4	0.6	4.4	22.4	16.1	3.0
	WASH.	58.4	31.3	2.3	6.3			1.7
1975	B.C.	42.5	10.6	0.6	3.6	25.8	14.2	2.7
	WASH.	65.9	24.9	2.0	5.9			1.3
1976	B.C.	40.5	11.1	0.6	2.6	25.9	16.6	2.7
	WASH.	63.9	27.9	1.5	5.4			1.3
1977	B.C.	43.9	12.1	0.5	2.1	21.9	15.7	3.7
	WASH.	61.0	30.3	1.8	5.2			1.7
1978	B.C.	41.9	11.8	0.5	1.4	25.0	16.8	2.6
	WASH.	63.7	27.9	1.8	5.0			1.6
1979	B.C.	42.8	12.9	0.6	1.9	21.7	16.3	4.0
	WASH.	64.2	29.3	1.3	3.5			1.7
1980	B.C.	42.8	12.0	0.5	1.5	24.7	14.1	4.3
	WASH.	66.9	26.5	1.5	3.5			1.6
1981	B.C.	42.8	13.4	0.5	1.0	22.9	17.1	2.4
	WASH.	65.5	28.0	1.4	3.4			1.7
1982	B.C.	41.9	12.4	0.4	0.7	25.0	16.6	3.0
	WASH.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1983	B.C.	42.9	11.1	0.5	0.4	24.6	17.4	2.9
	WASH.	n/a	n/a	n/a	n/a	n/a	n/a	n/a

[a] Washington State produces very little McIntosh and Spartan. In both cases, production has been accounted for under Others.
[b] For B.C., Others include summer apples, Tydeman's Red and Newtown.
For Washington state, Others include Granny Smith, Gravenstein, McIntosh, Spartan, Tydeman's Red, Johnathan, Winter Banana, Yellow Newtown and others.

SOURCES:
B.C.M.A.F., Production Of Tree Fruit Crops Together With An Estimate Of Farm Values.
Washington's Livestock and Crop Information Service.

2.3 ORCHARD COMPARISON

A recent tree survey determined the age breakdown for apple trees in B.C., as reported in Table 6 (Dawson, Dau and Associates). Out of all of the apple trees in B.C., 15.3 percent, 55226 trees, are aged 21 or older. When transformed into acres, 312.5 acres out of a total of 2042 acres of apples, the relatively high proportion of older trees poses a concern because the ability of a tree to bear a full crop generally declines with age. In addition, technological changes have caused many orchards throughout the world to shift toward high density systems, over the last decade. [7] Since many of the older trees are in low density (100-200 trees per acre) systems, the high proportion of older trees suggests that B.C. orchardists are falling behind in adopting the new technology of high density systems.

A decline in the proportion of older trees can be achieved by either renovating existing older orchards, by increasing new plantings, or both. Unfortunately, two factors exist to hinder these options. First, the cost of removing old trees and buying new trees is quite high in B.C. For example, at $5.5 per tree, $1111 (202 trees) would be required to renovate an acre. This amount does not include labour and other costs. Aside from the outlay for establishment, an orchardist must also forego the income

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[7] Mike Sanders, Regional Tree Fruit Specialist, B.C.M.A.F., Kelowna.

TABLE 6

NUMBER OF APPLE TREES IN B.C. BY AGE
(1984 TREE SURVEY)

	AGE OF TREES 1-5	6-10	11-15	16-20	21-25	25+	TOTAL
NO. OF TREES	103971	51340	75803	74968	28668	25668	361308
% OF TOTAL TREES	28.8	14.2	21.0	20.7	7.9	7.4	100

SOURCE: Dawson, Dau and Associates Limited, B.C. Tree Fruit Orchard Condition, March 1984.

that would otherwise be made if the land was left in production. Two, pressure from alternative uses, such as rural residences and recreation, has driven and kept land prices high in the Okanagan Valley. Hence, speculation on future development value has caused the land prices in this area to be some of the highest in B.C. The high land prices reduce an orchardist's ability to renovate due to cash flow problems. Alternatively, land speculation can reduce orchard renovation if the owner purchased purely for speculative reasons. In this instance, speculation reduces the incentive to renovate. On the expansion side, the high investment requirement generated by high land prices often results in a cash flow problem. Together, high replanting costs and land prices have reduced expansion and renovation of orchards in B.C.

Recent estimates of trees by age are not available for Washington State. However, estimates of the number of bearing and nonbearing apple trees are available. The number of bearing and nonbearing trees, as indicated by the 1982 census study, are 14,898,543 and 8,162,875, respectively.[8] In percentage terms, they represent 65 and 35 percent of total apple trees in Washington State. Depending on rootstocks, bearing trees are defined as 5 or 6 year old trees. If bearing trees are assumed to be 5 years or older, then B.C.'s proportion of nonbearing trees is 28.8 percent, approximately 6 percent below that of Washington State.

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[8] Jerry McCall, Statistician in Charge, Crop and Livestock Reporting Service, Seattle, Washington State.

Three major factors are attributed to the large number of new plantings in Washington State, an average of 6631 acres annually over the last six years (O'Rourke). The first is the completion of the Grand Coulee Dam which is capable of supplying water to areas, mostly in the Columbia Basin, that had none previously. The accessibility of water and the low user fees have generated many new plantings in the Columbia Basin. Second, the demand for alternative uses is not as intense for orchard lands in Washington State as in B.C. Therefore, less capital investment is required for expanding and establishing new orchards. Third, the tax structure in Washington State provides an incentive for individuals or organizations to invest in orchards. Trees between the age of one to five are allowed to depreciate at a rate of 15(year 1), 22(year 2), and 21(years 3-5) percent (Agriculture Canada, March 1984a). This provision encourages not only expansion but also renovations of existing orchards. This is not available in the B.C. tax structure. In addition, the annual capital cost allowance rates on other capital assets are higher in Washington State than in B.C. (Agriculture Canada, 1984a). Overall, these three factors act to encourage orchardists in Washington State to expand and renovate orchards. One disadvantage is that large corporations may invest in orchards as a means to increase asset depreciation, as seen in some instances in the Columbia Basin. Due to the large size of these investments, vertical integration of production, processing, and

marketing becomes a strong possibility. As a result, the present competitiveness of the market system may be eroded.

2.4 CLIMATE AND SOIL

Climate plays an important role in determining fruit size. Within B.C., the northern regions of the Okanagan Valley are generally cooler than the southern regions. The warmest areas are Oliver and Osoyoos. The climate in these two areas is very similar to areas just south of the border. But the climate in Washington State becomes much warmer than B.C. as one moves further south into the Columbia Basin. The warmer climate, especially right after the blossom period, provides an advantage to growers in Washington State. In general, the Red Delicious apples produced in Washington State are larger and darker in colour. The climatic advantage also generates higher annual yields and earlier harvests. One disadvantage of early warm periods is higher risk of frost damage[9], a result of early growth.

The soil in the Okanagan Valley is considered to be marginal for orchards.[10] The soil is characterized by

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[9]Frost damage refers to the damage resulting from the formation of ice crystals in the tissues of flowers or fruits

[10]Conversation with Mike Sanders, District Tree Fruit

shallow top soil, pH imbalance and is lacking in certain nutrients. Preservation of top soils is an important consideration to orchard managers. The pH imbalance and nutrient problems translate into higher production costs. Due to the limited availability of arable land, new plantings usually occur on old soil (i.e. soil previously used for tree fruits). Unless trees are treated chemically, the old soil will cause replanting diseases that can lead to lower yields and improper growth of trees. The cost of this chemical treatment is estimated to be $1.50 per tree with 60 cents going to chemical cost. In contrast, the soil in Washington State appears to be quite suitable for tree fruits. Replanting diseases are not a problem since most new plantings occur on virgin soil. In sum, the soil in B.C. adds additional costs, either directly in terms of chemicals, fumigants and/or fertilizers or indirectly in terms of reduced yields.

2.5 HIRED LABOUR

Compared to Washington State, the labour market in B.C. consists of a relatively large mixture of ethnic groups. No

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[10](cont'd) Specialist, B.C.M.A.F., Kelowna.

single ethnic group dominates the market as in Washington State. At certain periods of the crop year, many young French Canadians are available for work in B.C. These are often unskilled farm labourers. On the whole, the labour market consists of mostly skilled labourers, especially during the blossom and pruning period.

Similarly, the labour market in Washington State is dominated largely by skilled labourers. Most of the farm labourers are of Mexican origin who migrate from the south seasonally. For B.C. and Washington State, the supply of labour at critical periods does not appear to be a problem.

The labour market in B.C. is highly regulated by the Federal government. Minimum hourly wages are set annually by government officials. In addition to these regulated wages, health, unemployment insurance, pension, and workers' compensation regulations also exist for farm workers in B.C. The regulated benefits make the overall cost of hiring a farm worker in B.C. higher than in Washington State.

2.6 PROCESSING AND MARKETING

The majority of the apples produced in B.C. are shipped through cooperative packinghouses. In recent years, many

producers have become dissatisfied with the packinghouses, as a result of low producer prices. Through the cooperative system, producer prices are based on a pooling system. Consequently, the price received by producers is not only net of packinghouse expenses but also an average price based on all apples sold during a particular period. Because of this system of pooling, the quality and grades of apples being shipped by the producers become important factors in determining producer prices.

In the past, this system of pooling has lessened the incentives for producers to improve the quality of their apples. However, modifications of the pooling system are being introduced in an attempt to increase incentives to growers producing a higher proportion of top quality fruit.

In Washington State, apples are either packed by individual producers, cooperative packinghouses or independent packinghouses. By stressing quality, packinghouses have provided incentives for producers to renovate or replace trees producing low quality fruit. Hence, it may be a reason why producers in Washington State appear to be more willing to renovate their orchards.

2.7 GOVERNMENT SUPPORT PROGRAMS

One federal support program, the Agricultural Stabilization Act (ASA), exists to aid apple producers in B.C. The goal of this program is to guarantee a level of market return (calculated as a five year average) that is 90 or more percent of estimated production cost over a five year period. The annual average per pound cost of producing apples is determined using a cost of production model. The average total cost per pound includes variable costs, rent on land, interest on operating costs, and overhead costs. This program does not require apple producers to pay any premium. Payments are based on the differential between market returns and production cost, as estimated by the model.

The Farm Income Insurance (FII) program is the main source of provincial aid to B.C. apple producers. The FII program guarantees a market price equal to that of production cost. Market price is estimated as price received by producers plus ASA payments. The annual costs of production are negotiated through meetings between B.C.M.A.F. representatives and producer representatives. Costs obtained from concensus meetings are used to calculate the total per acre and per pound cost via the model developed by the Crop Insurance Branch. This provincial program is based on voluntary participation and requires

participants to pay a premium based on average production. The annual premium rates vary from year to year for both programs. The FII premiums have averaged 1.1 cents per pound over the period 1973-1984.

Two joint federal-provincial programs also exist to aid B.C. apple producers. The first is the Crop Insurance Program. This program provides an opportunity for producers to purchase insurance for their crops against unpredicted elements. Participants are required to pay an annual premium based on the production being insured. The second program provides assistance to producers for developing and expanding irrigation facilities in B.C. This program is referred to as the Agricultural and Regional Development Subsidiary Agreement.

In Washington State, no direct price or cost supporting programs exist for orchardists. Most government programs are indirect programs such as the building of dams and income tax incentives. An example is the Columbia Basin Project which included the construction of the Grand Coulee Dam near Grand Coulee, a large hydro electric power generating complex. This project provides a full supply of irrigation water to nearly 517,000 acres at present and plans have been developed to expand the irrigation to approximately 1.1 million acres in the near future (Dawson, Dau and Associates). Water from this project has been made available to orchardists within the irrigation district at a low fee.

Other forms of irrigation assistance are also available in Washington State. The level of assistance provided by the Bureau of Reclamation of the U.S. Department of Interior to irrigation districts has varied from a grant of 50% to over 90% of the total project costs. Interest free loans to producers over a 40 year period is another form of assistance.

As stated previously, the depreciability of trees provides an incentive for expansion and renovation of orchards in Washington State. The depreciation allowed will reduce the level of the orchardist's taxable income; hence, a lower level of income tax.

A summary table showing the effects discussed in this chapter has been included (Table 7). This table shows how climate, soil, land, input prices, processing and marketing, and government support programs can affect growers in B.C.

TABLE 7

EFFECTS ON THE B.C. APPLE INDUSTRY AS A RESULT OF DIFFERENCES IN CLIMATE, SOIL, ARABLE LAND, INPUT PRICES, PROCESSING AND MARKETING AND GOVERNMENT SUPPORT PROGRAMS

EFFECTS OF	CONSEQUENCES TO B.C.'S APPLE INDUSTRY
Climate	
-cooler in B.C.	-higher risk of freezing damage to trees -lower per acre yields -later production than Wash. -smaller and less dark fruit
Soil	
-marginal in B.C.	-higher cost from nutrient application -shallow top soil & pH imbalance require higher management skills -replanting diseases from old soil
Land	
-less arable land in B.C.	-higher land prices as a result of high demand for recreation and urban development
Input Prices	
-higher in B.C.	-per acre wages are higher as a result of government regulations -higher establishment cost as a result of higher tree prices -higher material costs result in higher per acre and per pound cost of producing apples
Processing & Marketing	
-pooling system in B.C.	-lower producer returns -reduced incentive to improve quality of fruit being shipped
Government Support Programs	
-less support for irrigation development in B.C.	-higher irrigation and water fees
-FII and ASA programs in B.C.	-guarantee a minimum annual average market price equal to that of production costs
-Crop Insurance program in B.C.	-reduce losses from unpredicted elements

3. CHAPTER III

3.1 LITERATURE REVIEW

One of the purposes of this study is to determine the cost of producing apples in B.C. and Washington State. For this reason, existing cost of production studies of apple orchards in B.C. and Washington State were examined. Three cost of production models were found to exist for B.C. apple orchards. Each was developed for a specific purpose. The first was developed by the Crop Insurance Branch of the B.C.M.A.F. for determining production cost for the FII program. The second was developed by the Economics Branch of the B.C.M.A.F. for analysis of production costs. A third model has been developed recently by the Stabilization Board of Agriculture Canada for determining payments for the ASA program. All three models employ a different approach to estimating costs. For example, the models developed to determine FII and ASA payments are concerned mainly with variable or cash costs. In contrast, the model developed by the Economics Branch includes fixed and economic costs, as well as variable costs. Because the models are user specific, it is difficult to compare results obtained from one model with another.

In contrast, by law, each state in the United States is required to compile cost of production studies for commodities (Hoffman and Gustafson, Harrington). Consequently, a relatively comprehensive production model has been developed for generating production studies. This model, referred to as the Budget Enterprise Generator[1], provides a standard method of estimating variable, fixed and economic costs associated with an enterprise. All Washington State's production cost studies on orchards are generated using this model.

Based on existing B.C. and Washington State orchard studies, it is difficult to compare estimated production costs between the two areas because the approaches employed to estimate variable, fixed and economic costs differ. Given that the second objective of this study is to compare production costs, the development of a standardized model is necessary. The model should standardize the methods employed to calculate variable, fixed and economic costs. Comparability is the underlying objective for standardizing the cost calculations. To find the best method employable, a literature survey was conducted.

A literature survey revealed that two conventional methods of estimating production cost have generated concerns (Hoffman and Gustafson, Harrington, Watts and Helmers, Walrath). The concerns revolve around a conceptual problem whereby conventional methods compare long run costs,

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[1] A publication titled Budget Enterprise Generator provides guidance to users of this production model.

including opportunity cost, with current returns for production. This is considered inadequate since some returns from investment in agricultural production resources, primarily capital appreciation of farmland, are neglected when total costs are only compared with short run or current returns from production. The separation of asset valuation used for economic cost analysis is considered essential if the costs of production results are to be meaningful indicators for policymakers in determining support levels (Hoffman and Gustafson).

An alternative method proposed is to compare current returns with the value of inputs used in current production and to distinguish the comparison from investment costs which generate future returns. This approach requires the exclusion of cost items or portions of a current cost used to generate future returns to assets. For example, the opportunity cost of land should be based only on the contribution of land to the current year's production.

In addition to the conceptual problem, other problems exist at the individual cost levels in production studies. These problems include the choice of an appropriate discount rate, the valuation of capital gains, valuation of land and management, and other costs. But, despite all the problems surrounding the calculation of some of the production costs, production studies do provide some useful information, as long as their weaknesses are recognized.

As an economic analysis, this study makes use of the conventional approach, (i.e. include long run costs in a short run analysis) to estimate costs of production associated with apples. Having chosen the conceptual framework, problems and issues surrounding land costs, operator labour, discount rates and machinery costs are examined. Although several economic theories are available, no standard methods are found to exist for calculating land costs, discount rates and many other costs. However, two common methods of estimating machine costs were found. These methods are usually refered to as the "Traditional" and "Capital Budgeting" approaches.

Machinery costs are usually classified into two broad categories known as ownership and operating costs. Ownership costs consist of depreciation cost, opportunity cost or interest on investment, insurance cost, property taxes, sales taxes and housing cost. These are costs associated with owning a piece of machinery and must be paid even if the firm is not operating. Hence, they are frequently known as fixed costs. Operating costs are costs associated with usage of a machine or implement. They include repair cost, maintenance cost, lubricant cost, fuel cost, and labour cost. In the Watts and Helmers' article, these costs are grouped differently. They used the term adjunct costs to include fuel, repairs, maintenance, insurance, property and sales taxes, and other cash costs. The other category is depreciation and interest cost. Regardless of the method of

grouping, the same issues and problems surrounding the methods of estimation exist.

The traditional budgeting approach estimates the annual cost of a depreciable asset using straight line depreciation with opportunity cost based on mid-value. The other fixed and variable costs are estimated on an annual basis as a function of purchase price, mid-value, or as an independent estimate. The capital budgeting approach discounts flows from point of occurrence during the machine's life. The sum of the discounted flows, net present cost, is then placed on an annual basis by amortizing the net present cost over the machine's life. The main advantage capital budgeting has over traditional budgeting is the capacity to include flows which are variable over time. In addition, income tax influences and inflation are conceptually easier to incorporate into capital budgeting.

Under the two approaches, depreciation and opportunity cost are handled quite differently. Mathematically, traditional budgeting estimates opportunity cost as follows: (Watts and Helmers)

$$(1) \qquad OC_T = (V(0) + V(n))/2 * r$$

where OC_T = the traditional budgeting estimate of opportunity cost

V(i) = value of the machine at age i

n = selling or replacement age

r = discount rate

Depreciation, D_T , is then given by

(2) $D_T = (V(0) - V(n)) / n$

Alternately, capital budgeting estimates annual depreciation and opportunity cost as [12]

(3) $D_c + OC_c = (V(0) - V(n)\, e^{-rn}) \left(\int_0^n e^{-ri}\, di\right)^{-1}$

where D_c = annual depreciation estimated by capital budgeting

OC_c = annual opportunity cost estimated by capital budgeting

e = 2.718 (base of natural logarithm)

The last term in equation (3), $\left(\int_0^n e^{-ri}\, di\right)^{-1}$, represents the amortization factor required to bring the cost into today's dollars. As shown by Watts and Helmer, depreciation plus opportunity cost estimated by capital budgeting, $D_c + OC_c$, is always greater than depreciation plus opportunity

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[12] The annual depreciation and opportunity cost estimated by capital budgeting can be separated as

$$D_c = \left\{\int_0^n D(i)\, e^{-ri}\, di\right\} \left\{\int_0^n e^{-ri}\, di\right\}^{-1}$$

$$OC_c = \left\{\int_0^n OC(i) e^{-ri}\, di\right\} \left\{\int_0^n e^{-ri}\, di\right\}^{-1}$$

cost estimated by the traditional approach, as long as the r is greater than zero. The two estimates are equal when r=0. Changes in opportunity cost caused by different machinery price functions are offset by changes in depreciation to maintain the same combined cost under capital budgeting. Differences in traditional and capital budgeting estimates of opportunity cost under straight line depreciation are entirely due to amortizing-discount effects.

The adjunct costs are treated as a constant over the ownership period in traditional budgeting. However, these costs could be variable or constant in the capital budgeting approach. Capital budgeting estimates annual adjunct costs by amortizing the present value of the adjunct costs as follows:

$$(4) \qquad A_c = \left(\int_0^n A(i)\, e^{-ri}\, di \right) \left(\int_0^n e^{-ri}\, di \right)^{-1}$$

where A_c = annual adjunct costs under capital budgeting
$A(i)$ = adjunct cost at machine age i
r = discount rate
n = ownership life of the machine
e = 2.718

The first term, $\left(\int_0^n A(i) e^{-ri}\, di \right)$, is the discounted present value of the adjunct cost and the second, $\left(\int_0^n e^{-ri}\, di \right)^{-1}$ is the amortization factor. If $A(i) = A$ for all i, then A_c can

be shown to equal A, which is the estimated cost under the traditional budgeting approach. This says that if the adjunct costs are constant, traditional and capital budgeting estimates will be identical. In general, estimates obtained from the two approaches do not indicate substantial differences. However, the differences do increase as the discount rate increases. Estimates obtained from the capital budgeting approach are considered to be more accurate since capital budgeting incorporates the concept of time.

3.2 METHODOLOGY

The cost of producing a pound of apples can be estimated from one of three approaches: (i) a general cost survey among apple orchards, (ii) case studies of specific orchards, and (iii) a study of a representative orchard. Depending on participation, the first method is commonly employed since it provides a relatively accurate estimate. However, the cost, and time required for such a study are relatively high. The existence of a provincial Farm Income Insurance program (FII) in B.C., whereby the government guarantees a market price equal to that of estimated production costs, precludes this approach since the FII program provides an incentive for orchardists to inflate actual production costs.

Case studies are quite informative, but tend to be highly firm specific. Given that individual orchards tend to vary in management practices, as a consequence of differences in soil types, variety grown, topography and management skills, it would be naive to assume results obtained from a specific orchard would reflect accurately the costs of other orchards. Usually, the third method requires a researcher to define a typical average firm that could be found within the industry. Hence, results obtained would reflect an average cost faced by producers within the industry. The major disadvantage of this method lies in the

relatively subjective definition of an average orchard. However, this problem can be overcome from discussions with experts within the industry.

The third approach, study of a representative orchard, is considered most applicable given the objectives of this study. From existing orchard production studies and discussions with regional agricultural economists, government field representatives and horticulturists in both B.C. and Washington State, a definition of a representative orchard is derived for each region. In each case, the orchard defined is considered representative of an average commercially viable orchard that is operable by a single operator. Each orchard is assumed to be an ongoing enterprise consisting of trees that range from one year old to mature. Mature trees are defined as those in full production and are at least nine years old. The land base, spacing and variety planted of the individual representative orchards are defined in Table 8.

For B.C., the land base, tree spacing, and variety are basically those used in the B.C.M.A.F. apple orchard cost studies. (B.C.M.A.F., 1982, 1984) However, the composition of the land base according to age of trees has been modified. An acre of eight year old trees has been added in keeping with the assumption that trees mature in year nine. [13] Keeping the ratio of establishment/mature trees at

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[13] According to Tim Watson, District Horticulturist, B.C.M.A.F, on average, trees will mature in year nine. The age in which the tree matures will depend on rootstock, training and management practices.

TABLE 8

DEFINITION OF AN AVERAGE COMMERCIALLY VIABLE ORCHARD IN B.C. AND WASHINGTON STATE

	B.C.	WASHINGTON STATE
LAND BASE	22 acres of land base - 0.5 acres personal residence - 1.5 acres headlands, buildings, roadways, storage areas - 20.0 acre orchard block	50 acres of land base - 1.0 acre personal residence - 3.0 acres headlands, buildings, roadways, storage areas - 46.0 acre orchard block
Composition of the orchard block	The 20 acre block consists of - 0.875 acre in year 1 establishment stage - 0.875 acre in year 2 establishment stage - 0.875 acre in year 3 establishment stage - 0.875 acre in year 4 establishment and first partial crop stage - 0.875 in year 5 establishment and second partial crop stage - 0.875 in year 6 establishment and third partial crop stage - 0.875 in year 7 establishment and fourth partial crop stage - 0.875 in year 8 establishment and fifth partial crop stage - 13 acres full crop production on mature trees	The 46 acre block consists of - 2 acres in year 1 establishment stage - 2 acres in year 2 establishment stage - 2 acres in year 3 establishment stage - 2 acres in year 4 establishment and first partial crop stage - 2 acres in year 5 establishment and second partial crop stage - 2 acres in year 6 establishment and third partial crop stage - 2 acres in year 7 establishment and fourth partial crop stage - 2 acres in year 8 establishment and fifth partial crop stage - 30 acres full crop production on mature trees
Tree removal	- trees being removed are in a 30' x 30' spacing	- ground is assumed to be bush land
Tree spacing and variety	- Trees being planted are in a 12' x 18' spacing which allows for 202 trees per acre - The scion variety is spur Red Delicious on a M2 or A2 rootstock - Pollinizers are interspersed throughout the orchard - Mature trees are in the same spacing and on the same rootstock	- Trees being planted are in a 9' x 18' spacing which allows for 284 trees (269 red delicious, 15 pollinizers) - The trees are free standing, spur Red Delicious on seedling or M7A. Oregon Spur is the most common variety of spur delicious - Pollinizers are interspersed throughout the orchard - Mature trees are in the same spacing and on the same rootstock

0.53, the number of acres of mature trees remains unchaged at 13 acres.

According to B.C.M.A.F.'s horticulturists and field representatives, the size of the land base (22 acres) and its composition are representative of apple orchards in the Okanagan Valley. In the case of Washington State, the defined land base (50 acres) is used frequently in orchard studies compiled by researchers in that State. (Hinman, Hunter and Tukey, 1981, 1982, 1985) The composition of the land base according to age of trees for Washington State is based on the same establishment/mature trees ratio as for B.C. The spacing and rootstocks, in each case, are compiled from existing apple orchard studies and visits with extension agents in Washington State.

3.2.1 DATA

In a cost of production study, the set of production data required includes management practices by age of trees; machine and labour hours per practice; service or material costs associated with each practice; average yields; and other farm level costs. Given the data requirement for this study, a limited amount was found to be available. Without a

full scale or selected survey and the limited availability of existing cost data associated with each management practice, alternate approaches had to be considered. One alternative was to extract data from existing orchard production studies in both B.C. and Washington State. This raised the issue of the quality of data in existing studies. As noted earlier, three cost of production models exist for apple production in B.C. The data used in the Crop Insurance model to determine annual FII payments were rejected as a data source because of possible existence of bias in favour of the producers. The reason is that the data are based on negotiations between representatives of government and producers.

The production data in the model developed and used by the Economics Branch of the B.C.M.A.F. are gathered from consensus meetings between producers, horticulturalists, and field representatives. A bias may still exist in these data, but it will be less given the presence of other orchard experts. This information provides a useful base for production data. Hence, unless specified otherwise, this is the B.C.M.A.F. model referred to in the remainder of this study. To ensure that the data are relatively accurate, further input was obtained from district horticulturists, packinghouse, field representatives, and regional agricultural economists.

Similar procedures were employed in gathering the data set for the Washington State's representative orchard.

Existing orchard production studies were used to compile management practices, machine requirements, labour requirements and input costs. As in B.C., additional input was obtained from both extension and research horticulturalists and agricultural economists.

From the data collected and discussions with field representatives, it appears that, despite the mandatory switch to metric, most industry people still think and use the imperial measurement system. To enhance the useability of this report, the imperial measurements (i.e. pounds, acres) are used. This will allow interested persons in Washington State to more easily comprehend the comparisons. For completeness, the result tables are also presented in metric in Appendix A.

3.2.2 METHODS OF ESTIMATION

Having defined a representative orchard for B.C. and Washington State (Table 8), an associated set of management practices, along with a set of machinery, equipment and buildings, were compiled for each region. For comparison purposes, the defined management practices of the two regions are presented together in a series of tables, Tables

9 to 17, referred to as the management schedules. The set of management schedules consists of nine separate schedules depicting the practices applied to trees aged one through mature on a per acre basis, in B.C. and Washington State. The schedules also include the type of machine used, machine hours, labour hours, and material/service costs associated with each operation. For example, in Table 9, tree and root removal occurs once per acre and is assumed to take the same amount of labour (48 hours per acre) and require the same cost of service/material ($250 per acre) for both B.C. and Washington State. Ground preparation is assumed to require a tractor and rotovator in B.C. but is assumed to be custom hired in Washington State. In each case, this operation occurs twice and the machine hours required per acre is 2.8 hours for B.C. and zero for Washington State. The service/material cost associated with ground preparation is $20.74 Canadian dollars for Washington State and zero for B.C.

For B.C., the operations/practices, machine used, and service/material costs are those defined in the B.C.M.A.F.'s 1982 and 1984 apple orchard studies. Machine hours required per operation are estimated by taking the hours stated in the B.C.M.A.F. studies and subtracting the product of the original hours and 0.2. [14] The objective of this calculation is to eliminate the time required to mount an implement or make an adjustment, which would have been included in the

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[14] This adjustment was suggested by Howard Joynt, Agricultural Officer, B.C.M.A.F., Summerland.

TABLE 9

MANAGEMENT SCHEDULE FOR TREES IN YEAR 1 ESTABLISHMENT CROP STAGE, B.C. AND WASHINGTON STATE

OPERATION(a,b)	MACHINE USED		TIMES USED PER ACRE		MACHINE HOURS PER ACRE		LABOUR HOURS PER ACRE		SERVICE/ MATERIAL COST PER ACRE	
	B.C.(a)	WASH.(b)	B.C.(a)	WASH.(b)	B.C.(a)	WASH.(b)	B.C.(a,c)	WASH.(b)	B.C.(a) Cans 1984	WASH.(b) Cans (d) 1984
Tree & Root Removal (e)			1	1			48.00	48.00	250.00	250.00
Ground Preparation	tractor rotovator	custom hired	2	2	2.80		3.36	0.84		20.74
Layout/staking & stakes	hand labour	hand labour	1	3			8.00	1.50	4.65	0.12
Plant trees	tractor auger	rented 110hp tractor w/planter	1	1	3.40		29.76	6.20	1131.00	1476.81
Hauling plants		pickup		1		1.00		1.20		
Fertilizer Application	hand labour	hand labour	1	2			0.27	1.00	5.73	114.44
Handseed 5.4kg fescue mix	hand labour		1				0.50		30.00	
Weeding hand hoeing	hand labour		3				10.08			
Sucker training & pruning	hand labour		1				3.36		7.87	
Mowing	tractor 50hp mower 80in	tractor 60hp mower 108in	2	3	1.60	1.50	1.92	1.80		
Nutrient Application	tractor 50hp orch. sprayer		3		0.80		0.96		24.51	
Thiodan 6 oz	tractor 50hp orch. sprayer		1		0.26		0.32		2.52	
Boron 25 lbs	tractor 50hp fert. spreader		1		0.22		0.26		12.10	
Herbicide Application		tractor 60hp weed sprayer		2		0.66		0.80		17.25
Irrigation & water fee (f)	solid set	solid set	14	14	168.00	168.00	1.50	3.00	70.00	34.39
Mouse guard	hand labour		1				0.40		110.40	
Rodent control	hand labour	custom aerial	1	1			0.40		2.29	20.37
Sopher control		tractor 60hp gopher machine		1		0.25		0.30		5.61
Use of pickup	pickup 1/2 ton	pickup 1/2 ton			8.60	9.00	10.32	10.80		

SOURCES: (a) B.C.M.A.F. "Estimated Costs and Returns: Apple Orchard Establishment and Production." Study No. 266, May 1984.

(b) Compiled from Hinman, H.R.; Hunter, R. E.; and Tukey, R. B. "1985 Cost of Establishing An Apple Orchard Columbia Basin, Washington." College of Agriculture, Washington State University, Pullman, Washington Extension Bulletin 0960. January, 1985.

(c) Labour hours per acre = machine hours per acre * 1.2

(d) The exchange rate, 1984 monthly noon average, is 1.22 Cans per US$.

(e) Labour and service/material costs for Washington State are assumed to be the same as B.C.

(f) An estimate provided by Ted M. Van der Gulik, Agricultural Engineer, B.C.M.A.F.

TABLE 10

MANAGEMENT SCHEDULE FOR TREES IN YEAR 2 ESTABLISHMENT STAGE, B.C. AND WASHINGTON STATE

OPERATION(a,b)	MACHINE USED		TIMES USED PER ACRE		MACHINE HOURS PER ACRE		LABOUR HOURS PER ACRE		SERVICE/ COST PER ACRE	MATERIAL
	B.C.(a)	WASH.(b)	B.C.(a)	WASH.(b)	B.C.(a)	WASH.(b)	B.C.(a,c)	WASH.(b)	B.C.(a) Can$ 1984	WASH.(b) Can$ (d) 1984
Replanting 8 5% & plant collerizers	hand labour	tractor 60hp rent auger	1	1		1.00	0.75	3.20	56.56	175.63
Haul & water plants		pickup		1		1.00		1.20		
Pruning & training	hand labour	hand labour	1	1			6.75	5.00	24.03	
Disc		tractor 60hp rented 12ft disc		2		0.20		0.24		6.10
Seed grass		tractor 60hp rented seeder		1		0.25		0.30		13.58
Fert. application	tractor 50hp fert. spreader	tractor 60hp fert. spreader	2	1	0.43	0.25	0.52	0.30	17.23	25.62
Nutrient application	tractor 50hp orch. sprayer		3		0.80		0.96		24.51	
Herbicide application	tractor 50hp weed sprayer	tractor 60hp weed sprayer	3	2	3.60	0.66	4.32	0.80	28.21	17.25
Aphid control	tractor 50hp orch. sprayer	custom aerial	1	1	0.26		0.32		2.52	20.30
Mowing	tractor 50hp mower 80in	tractor 60hp mower 108in	4	3	3.20	1.50	3.84	1.80		
Irrigation & water fee (e)	solid set	solid set	14	14	168.00	168.00	1.50	3.00	70.00	34.99
Rodent control	hand labour	custom aerial	1	1			0.40		2.29	20.37
Gopher control		tractor 60hp gopher machine		1		0.25		0.30		5.61
Transp. use of pickup	pickup 1/2 ton	pickup 1/2 ton			8.60	9.00	10.32	10.80		

SOURCES: (a) B.C.M.A.F. "Estimated Costs and Returns: Apple Orchard Establishment and Production." Study No. 266, May 1984.
(b) Compiled from Hinman, H.R.; Hunter, R. E.; and Tukey, R. B. "1985 Cost of Establishing An Apple Orchard Columbia Basin, Washington." College of Agriculture, Washington State University, Pullman, Washington Extension Bulletin 0960, January, 1985.
(c) Labour hours per acre = machine hours per acre * 1.2
(d) The exchange rate, 1984 monthly noon average, is 1.22 Can$ per US$.
(e) An estimate provided by Ted W. Van der Gulik, Agricultural Engineer, B.C.M.A.F.

TABLE 11

MANAGEMENT SCHEDULE FOR TREES IN YEAR 3 ESTABLISHMENT STAGE, B.C. AND WASHINGTON STATE

OPERATION(a,b)	MACHINE USED B.C.(a)	MACHINE USED WASH.(b)	TIMES USED PER ACRE B.C.(a)	TIMES USED PER ACRE WASH.(b)	MACHINE HOURS PER ACRE B.C.(a)	MACHINE HOURS PER ACRE WASH.(b)	LABOUR HOURS PER ACRE B.C.(a,c)	LABOUR HOURS PER ACRE WASH.(b)	SERVICE/ COST PER ACRE B.C.(a) Can$ 1984	MATERIAL ACRE WASH.(b) Can$ (d) 1984
Pruning & training	pruning tools	pruning tools	1	1			8.47	15.50	15.91	80.52
Fertilizer application	tractor 50hp fert. spreader	tractor 60hp fert. spreader	2	1	0.43	0.25	0.52	0.30	22.90	25.62
Dormant oil 2 gal	tractor 50hp orch. sprayer		1		1.20		1.44		7.80	
Fruit removal		hand labour		1				1.00		
Nutrient application (e)	tractor 50hp orch. sprayer		4		2.00		2.40		53.94	
Herbicide application	tractor 50hp weed sprayer	tractor 60hp weed sprayer	3	3	3.60	0.99	4.32	1.20	28.21	28.51
Aphid control	tractor 50hp orch. sprayer	custom aerial	1	1	0.26		0.32		5.05	22.74
Flictran 4 oz	tractor 50hp orch. sprayer		1		1.20		1.44		6.05	
Mowing	tractor 50hp mower 80in	tractor 60hp mower 100in	4	3	3.20	1.50	3.84	1.80		
Irrigation & water fee (f)	solid set	solid set	14	14	168.00	168.00	1.50	3.00	70.00	34.99
Rodent control	hand labour	custom aerial	1	1			0.40		2.29	20.37
Gopher control		tractor 60hp gopher machine		1		0.25		0.30		5.61
Transp. use of pickup	pickup 1/2 ton	pickup 1/2 ton			8.50	10.00	10.32	12.00		

SOURCES: (a) B.C.M.A.F. "Estimated Costs and Returns: Apple Orchard Establishment and Production." Study No. 266, May 1984.
(b) Compiled from Hinman, H.R.; Hunter, R. E.; and Tukey, R. B. "1983 Cost of Establishing An Apple Orchard Columbia Basin, Washington." College of Agriculture, Washington State University, Pullman, Washington Extension Bulletin 0940, January, 1983.
(c) Labour hours per acre = machine hours per acre * 1.2
(d) The exchange rate, 1984 monthly mean average, is 1.22 Can$ per US$.
(e) Includes an application of zinc sulphate.
(f) An estimate provided by Tod H. Van der Gulik, Agricultural Engineer, B.C.M.A.F.

TABLE 12

MANAGEMENT SCHEDULE FOR TREES IN YEAR 4 ESTABLISHMENT AND FIRST PARTIAL CROP STAGE, B.C. AND WASHINGTON STATE

OPERATION(a,b)	MACHINE USED B.C.(a)	MACHINE USED WASH.(b)	TIMES USED PER ACRE B.C.(a)	TIMES USED PER ACRE WASH.(b)	MACHINE HOURS PER ACRE B.C.(a)	MACHINE HOURS PER ACRE WASH.(b)	LABOUR HOURS PER ACRE B.C.(a,c)	LABOUR HOURS PER ACRE WASH.(b)	SERVICE/ COST PER ACRE B.C.(a) Can$ 1984	MATERIAL ACRE WASH.(b) Can$ (d) 1984
Pruning & training	hand labour	hand labour	1	1			10.10	26.50		80.52
Fertilizer application	tractor 50hp fert. spreader	tractor 35hp fert. spreader	2	1	0.43	0.25	0.52	0.30	28.57	25.62
Cover spray		tractor 60hp blast sprayer		2		0.80		0.96		29.77
Preplnk spray		tractor 60hp blast sprayer		1		0.40		0.48		21.37
Fruit thinning	hand labour	hand labour	1	1			3.37	4.00		
Nutrient application	tractor 50hp orch. sprayer		3		3.60		4.32		37.98	
Herbicide application	tractor 50hp weed sprayer	tractor 35hp weed sprayer	3	2	3.60	0.66	4.32	0.80	28.21	15.81
Insecticide application	tractor 50hp orch. sprayer	tractor 60hp blast sprayer	7	1	8.40	0.40	10.08	0.48	137.40	14.29
Fungicide application	tractor 50hp orch. sprayer		2		2.40		2.88		19.04	
Boron 25 lbs	tractor 50hp fert. spreader		1		0.22		0.26		12.07	
Mowing	tractor 50hp mower 80in	tractor 60hp mower 100in	4	3	3.20	1.50	3.84	1.80		
Irrigation & water fee (e)	solid set	solid set	14	14	168.00	168.00	1.50	3.00	70.00	34.99
Harvesting/picking	picking sacks	picking sacks	1	1					33.00	61.49
Bin hauling/handling	tractor 50hp rear frks front ldr & frks	tractor 60hp backfork	1	1	0.24	0.50	0.29	0.60		
Bin hauling		tractor 35hp backfork		1		0.50		0.60		
Custom hauling	2 bins	5 bins	1	1					7.00	15.25
rodent control	hand labour	custom aerial	1	1			0.40		2.29	20.37
Gopher control		tractor 60hp gopher machine		1		0.25		0.30		5.61
Transp. use of pickup	pickup 1/2 ton	pickup 1/2 ton			8.60	10.00	10.32	12.00		
Misc. use of trailer		tractor 60hp trailer				1.00		1.20		

SOURCES: (a) B.C.M.A.F. "Estimated Costs and Returns: Apple Orchard Establishment and Production." Study No. 266. May 1984.

(b) Compiled from Hinman, H.R.; Hunter, R. E.; and Tukey, R. B. "1983 Cost of Establishing An Apple Orchard Columbia Basin, Washington." College of Agriculture, Washington State University, Pullman, Washington Extension Bulletin 0960. January, 1985.

(c) Labour hours per acre = machine hours per acre * 1.2

(d) The exchange rate, 1984 monthly noon average, is 1.22 Can$ per US$.

(e) An estimate provided by Ted W. Van der Gulik, Agricultural Engineer, B.C.M.A.F.

TABLE 17

MANAGEMENT SCHEDULE FOR TREES IN YEAR 5 ESTABLISHMENT AND SECOND PARTIAL CROP STAGE, B.C. AND WASHINGTON STATE

OPERATION(a,b)	MACHINE USED B.C.(a)	MACHINE USED WASH.(b)	TIMES USED PER ACRE B.C.(a)	TIMES USED PER ACRE WASH.(b)	MACHINE HOURS PER ACRE B.C.(a)	MACHINE HOURS PER ACRE WASH.(b)	LABOUR HOURS PER ACRE B.C.(a,c)	LABOUR HOURS PER ACRE WASH.(b)	SERVICE/ COST PER ACRE B.C.(a) Cans 1984	MATERIAL ACRE WASH.(b) Cans(d) 1984
Pruning & training	pruning tools	pruning tools	1	1			19.27	36.50		7.32
Fertilizer application	tractor 50hp fert. spreader	tractor 35hp fert. spreader	2	1	0.43	0.25	0.52	0.30	28.62	42.70
Cover spray		tractor 60hp blast sprayer		2		0.80		0.96		29.77
Preplnt spray		tractor 60hp blast sprayer		1		0.40		0.48		21.37
Pollination			1	1					36.00	49.41
Fruit thinning	hand labour	tractor 60hp blast sprayer	1	2		0.80	10.10	0.96		15.81
Nutrient application	tractor 50hp orch. sprayer		3		3.60		4.32		37.98	
Herbicide application	tractor 50hp weed sprayer	tractor 35hp weed sprayer	3	2	3.60	0.66	4.32	0.80	28.21	15.81
Insecticide application	tractor 50hp orch. sprayer	tractor 60hp blast sprayer	7	1	8.40	0.40	10.08	0.45	137.40	17.76
Fungicide application	tractor 50hp orch. sprayer		2		2.40		2.88		19.04	
Mowing	tractor 50hp mower 80in	tractor 60hp mower 108in	4	3	3.20	1.50	3.84	1.80		
Irrigation & water fee (e)	solid set	solid set	14	14	168.00	168.00	1.50	3.00	70.00	34.99
Harvesting/picking	picking sacks	picking sacks							110.00	183.00
Bin distribution/ handling	tractor 50hp rear frks frnt ldr & frks	tractor 35hp backfork	1	1	1.67	3.00	2.00	3.60		
Load		tractor 60hp highlift fork		1		3.00		3.60		
Sweep		tractor 35hp backfork		1		3.00		3.60		
Custom hauling	10 bins	15 bins	1	1					35.00	45.75
Rodent control	hand labour	custom aerial	1	1			0.40		2.29	20.37
Gopher control		tractor 60hp gopher machine		1		0.25		0.30		5.61
Cleanup		tractor 35hp trailer		1		0.50		0.60		
Transp. use of pickup	pickup 1/2 ton	pickup 1/2 ton			8.60	10.00	10.32	12.00		
Misc. use of trailer		tractor 60hp trailer				0.50		0.60		

SOURCES: (a) B.C.M.A.F. "Estimated Costs and Returns: Apple Orchard Establishment and Production." Study No. 244, May 1984.

(b) Compiled from Hinman, H.R.; Hunter, R. E.; and Tukey, R. B. "1985 Cost of Establishing An Apple Orchard Columbia Basin, Washington." College of Agriculture, Washington State University, Pullman, Washington Extension Bulletin 0960, January, 1985.

(c) Labour hours per acre = machine hours per acre * 1.2

(d) The exchange rate, 1984 monthly noon average, is 1.22 Cans per US$.

(e) An estimate provided by Ted W. Van der Gulik, Agricultural Engineer, B.C.M.A.F.

TABLE 14

MANAGEMENT SCHEDULE FOR TREES IN YEAR 6 ESTABLISHMENT AND THIRD PARTIAL CROP STAGE, B.C. AND WASHINGTON STATE

OPERATION(a,b)	MACHINE USED		TIMES USED PER ACRE		MACHINE HOURS PER ACRE		LABOUR HOURS PER ACRE		SERVICE/ COST PER ACRE	MATERIAL ACRE
	B.C.(a)	WASH.(b)	B.C.(a)	WASH.(b)	B.C.(a)	WASH.(b)	B.C.(a,c)	WASH.(b)	B.C.(a) Can$ 1984	WASH.(b) Can$ (d) 1984
Pruning & training	pruning tools	pruning tools	1	1			26.93	33.17		7.30
Fertilizer application	tractor 50hp fert. spreader	tractor 35hp fert. spreader	2	1	0.43	0.25	0.52	0.30	34.35	42.70
Cover spray		tractor 60hp blast sprayer		2		0.80		0.96		29.77
Prepink spray		tractor 60hp blast sprayer		1		0.40		0.48		21.37
Pollination			1	1					36.00	49.41
Fruit thinning	hand labour	tractor 60hp blast sprayer	1	2		0.80	13.47	0.96		15.81
Nutrient application	tractor 50hp orch. sprayer		3		3.60		4.32		37.98	
Herbicide application	tractor 50hp weed sprayer	tractor 35hp weed sprayer	3	2	3.60	0.66	4.32	0.80	28.21	15.81
Insecticide application	tractor 50hp orch. sprayer	tractor 60hp blast sprayer	7	1	8.40	0.40	10.08	0.48	137.40	17.76
Fungicide application	tractor 50hp orch. sprayer		2		2.40		2.88		19.04	
Mowing	tractor 50hp mower 80in	tractor 60hp mower 108in	4	3	3.20	1.50	3.84	1.80		
Irrigation & water fee (e)	solid set	solid set	14	14	168.00	168.00	1.50	1.00	70.00	90.22
Harvesting/picking	picking sacks	picking sacks	1	1					2.90	20.37
Bin distribution/ handling	tractor 50hp rear frks frnt ldrs & frks	tractor 35hp backfork	1	1	3.35	4.40	4.00	5.28		5.61
Load		tractor 60hp highlift fork		1		4.40		5.28		
Swamp		tractor 35hp backfork		1		4.40		5.28		
Custom hauling	20 bins	26.3 bins	1	1						
Rodent control	hand labour	custom aerial	1	1			0.40			
Gopher control		tractor 60hp gopher machine		1		0.25		0.30		
Cleanup		tractor 35hp trailer		1		0.50		0.60		
Transp. use of pickup	pickup 1/2 ton	pickup 1/2 ton			8.60	10.00	10.32	12.00		
Misc. use of trailer		tractor 60hp trailer				0.50		0.60		

SOURCES: (a) B.C.M.A.F. "Estimated Costs and Returns: Apple Orchard Establishment and Production." Study No. 266, May 1984.
(b) Compiled from Hinman, H.R.; Hunter, R. E.; and Tukey, R. B. "1985 Cost of Establishing An Apple Orchard Columbia Basin, Washington." College of Agriculture, Washington State University, Pullman, Washington Extension Bulletin 0867, January, 1985.
(c) Labour hours per acre = machine hours per acre * 1.2
(d) The exchange rate, 1984 monthly noon average, is 1.22 Can$ per US$.
(e) An estimate provided by Ted H. Van der Gulik, Agricultural Engineer, B.C.M.A.F.

TABLE 13

MANAGEMENT SCHEDULE FOR TREES IN YEAR 7 ESTABLISHMENT AND FOURTH PARTIAL CROP STAGE, B.C. AND WASHINGTON STATE

OPERATION (a,b)	MACHINE USED B.C.(a)	WASH.(b)	TIMES USED PER ACRE B.C.(a)	WASH.(b)	MACHINE HOURS PER ACRE B.C.(a)	WASH.(b)	LABOUR HOURS PER ACRE B.C.(a,c)	WASH.(b)	SERVICE/ COST PER B.C.(a) Cans 1984	MATERIAL ACRE WASH.(b) Cans (d) 1984
Pruning & training	mechanical ladder, power pruner	pruning tools	1	1	16.00		30.30	69.84		7.32
Fertilizer application	tractor 50hp fert. spreader	tractor 35hp fert. spreader	2	1	0.47	0.25	0.52	0.30	34.35	42.70
Cover spray		tractor 60hp blast sprayer		2		0.80		0.96		29.77
Preplnt spray		tractor 60hp blast sprayer		1		0.40		0.48		21.37
Pollination			1	1					36.00	49.41
Fruit thinning	hand labour	tractor 60hp blast sprayer	1	2		0.80	13.46	0.94		15.81
Nutrient application	tractor 50hp orch. sprayer		3		3.60		4.32		37.98	
Herbicide application	tractor 50hp weed sprayer	tractor 35hp weed sprayer	3	2	3.60	0.66	4.32	0.80	28.21	15.81
Insecticide application	tractor 50hp orch. sprayer	tractor 60hp blast sprayer	7	1	8.40	0.40	10.08	0.48	137.40	17.76
Fungicide application	tractor 50hp orch. sprayer		2		2.40		2.88		19.04	
Elgetol .74 gal	tractor 50hp orch. sprayer		1		1.20		1.44		27.70	
Boron 11 kg	tractor 50hp fert. spreader		1		0.22		0.26		12.10	
Mowing	tractor 50hp mower 80in	tractor 60hp mower 108in	4	3	3.20	1.50	3.84	1.80		
Irrigation & water fee (e)	solid set	solid set	14	14	168.00	168.00	1.50	3.00	70.00	34.95
Harvesting/picking	mechanical ladder	picking sacks	1	1	6.40				357.50	457.50
Bin distribution/ handling	tractor 50hp rear frks frnt ldr & frks	tractor 35hp back fork	1	1	5.00	5.03	6.00	6.14		
Load		tractor 60hp highlift fork		1		5.03		6.14		
Swamp		tractor 35hp backfort		1		5.03		6.14		
Custom hauling	32.5 bins	37.5 bins	1	1					113.75	114.38
Rodent control	hand labour	custom aerial	1	1			0.40		2.90	20.37
Gopher control		tractor 60hp gopher machine		1		0.25		0.30		5.61
Cleanup		tractor 35hp trailer		1		0.50		0.60		
Transp. use of pickup	pickup 1/2 ton	pickup 1/2 ton			8.60	10.00	10.32	12.00		
Misc. use of trailer		tractor 60hp trailer				0.50		0.60		

SOURCES: (a) B.C.M.A.F. "Estimated Costs and Returns: Apple Orchard Establishment and Production." Study No. 366, May 1984.

(b) Compiled from Hinman, H.R.; Hunter, R. E.; and Tukey, R. B. "1985 Cost of Establishing An Apple Orchard Columbia Basin, Washington." College of Agriculture, Washington State University, Pullman, Washington Extension Bulletin 0760, January, 1985.

(c) Labour hours per acre = machine hours per acre * 1.2

(d) The exchange rate, 1984 monthly noon average, is 1.22 Cans per US$.

(e) An estimate provided by Ted W. Van der Gulik, Agricultural Engineer, B.C.M.A.F.

TABLE 15

MANAGEMENT SCHEDULE FOR TREES IN YEAR 8 ESTABLISHMENT AND FIFTH PARTIAL CROP STAGE, B.C. AND WASHINGTON STATE

OPERATION(a,b)	MACHINE USED B.C.(a)	MACHINE USED WASH.(b)	TIMES USED PER ACRE B.C.(a)	TIMES USED PER ACRE WASH.(b)	MACHINE HOURS PER ACRE B.C(a)	MACHINE HOURS PER ACRE WASH.(b)	LABOUR HOURS PER ACRE B.C.(a,c)	LABOUR HOURS PER ACRE WASH.(b)	SERVICE/ COST PER ACRE B.C.(a) Can$ 1984	MATERIAL ACRE WASH.(b) Can$ (d) 1984
Pruning & training	mechanical ladder, power pruner	hand labour pruning tools	1	1	17.78		33.67	86.50		7.32
Fertilizer application	tractor 50hp fert. spreader	tractor 35hp fert. spreader	2	1	0.43	0.25	0.52	0.30	34.35	42.70
Cover spray		tractor 60hp blast sprayer		2		0.80		0.96		29.77
Preplnt spray		tractor 60hp blast sprayer		1		0.40		0.48		21.37
pollination			1	1					36.00	49.41
Thin spray (growth reg)	tractor 50hp orch. sprayer	tractor 60hp blast sprayer	1	2	1.20	0.80	1.44	0.96	44.82	15.61
Hand thinning	hand labour	hand labour ladders	1	1			34.00	46.29		
Nutrient application	tractor 50hp orch. sprayer		3		3.60		4.32		37.94	
Herbicide application	tractor 50hp weed sprayer	tractor 35hp weed sprayer	3	2	3.60	0.66	4.32	0.80	26.21	15.61
Insecticide application	tractor 50hp orch. sprayer	tractor 60hp blast sprayer	7	1	8.40	0.40	10.08	0.48	137.40	17.76
Fungicide application	tractor 50hp orch. sprayer		2		2.40		2.88		19.04	
Mowing	tractor 50hp mower 80in	tractor 60hp mower 108in	4	3	3.20	1.50	3.84	1.80		
Irrigation & water fee (e)	solid set	solid set	14	14	168.00	168.00	1.50	3.00	70.00	34.99
Bin distribution		tractor 35hp backfork		1		5.60		6.72		
Harvesting/picking	mechanical ladder, bags	ladders picking sacks	1	1	8.00				440.00	595.76
Swaps		tractor 35hp back fork		1		5.60		6.72		
Bin loading/handling	tractor 50hp rear frks frnt ldr & frks	tractor 60hp highlift fork	1	1	5.34	5.60	6.40	6.72		
Custom hauling	40 bins	48.75 bins	1	1					140.00	148.84
Cleanup		tractor 35hp trailer		1		0.50		0.60		
Rodent control	hand labour	custom aerial	1	1			0.40		2.99	20.37
Gopher control		tractor 60hp gopher machine		1		0.25		0.30		5.61
Transp. use of pickup	pickup 1/2 ton	pickup 1/2 ton			8.50	10.00	10.32	12.00		
Misc. use of trailer		tractor 60hp trailer				0.50		0.60		

SOURCES: (a) B.C.M.A.F. "Estimated Costs and Returns: Apple Orchard Establishment and Production." Study No. 266, May 1984.

(b) Compiled from Minaan, M.M.; Hunter, R. E.; and Tukey, R. B. "1985 Cost of Establishing An Apple Orchard Columbia Basin, Washington." College of Agriculture, Washington State University, Pullman, Washington Extension Bulletin 0969, January, 1985.

(c) Labour hours per acre = machine hours per acre * 1.2

(d) The exchange rate, 1984 monthly noon average, is 1.22 Can$ per US$.

(e) An estimate provided by Ted W. Van der Gulik, Agricultural Engineer, B.C.M.A.F.

Table 17

MANAGEMENT SCHEDULE FOR MATURE TREES, B.C. AND WASHINGTON STATE

OPERATION(a,b)	MACHINE USED B.C.(a)	MACHINE USED WASH.(b)	TIMES USED PER ACRE B.C.(a)	TIMES USED PER ACRE WASH.(b)	MACHINE HOURS PER ACRE B.C.(a)	MACHINE HOURS PER ACRE WASH.(b)	LABOUR HOURS PER ACRE B.C.(a,c)	LABOUR HOURS PER ACRE WASH.(b,c)	SERVICE/ COST PER ACRE B.C.(a) Cand 1984	MATERIAL ACRE WASH.(b,d) Cand (e) 1984
Pruning & training	mechanical ladder, power pruner	hand labour pruning tools	1	1	17.78		33.67	86.50		7.32
Fertilizer application	tractor 50hp fert. spreader	tractor 35hp fert. spreader	2	1	0.43	0.25	0.52	0.30	34.35	42.70
Cover spray		tractor 60hp blast sprayer		2		0.80		0.96		29.77
Prepink spray		tractor 60hp blast sprayer		1		0.40		0.48		21.37
pollination			1	1					36.00	49.41
Thin spray (growth reg)	tractor 50hp orch. sprayer	tractor 60hp blast sprayer	1	2	1.20	0.80	1.44	0.94	44.82	15.81
Hand thinning	hand labour	hand labour ladders	1	1			34.00	46.29		
Nutrient application	tractor 50hp orch. sprayer		3		3.60		4.32		37.98	
Herbicide application	tractor 50hp weed sprayer	tractor 35hp weed sprayer	3	2	3.60	0.66	4.32	0.80	28.21	15.81
Insecticide application	tractor 50hp orch. sprayer	tractor 60hp blast sprayer	7	1	8.40	0.40	10.08	0.48	137.40	17.76
Fungicide application	tractor 50hp orch. sprayer		2		2.40		2.88		19.04	
Boron 25 lbs every 3rd yr	tractor 50hp fert. spreader		1		0.08		0.10		4.03	
Mowing	tractor 50hp mower 80in	tractor 60hp mower 108in	4	3	3.20	1.50	3.84	1.80		
Irrigation & water fee (e)	solid set	solid set	14	14	168.00	168.00	1.50	3.00	70.00	14.99
Bin distribution		tractor 35hp backfork		1		6.00		7.20		
Harvesting/picking	mechanical ladder, bags	picking sacks	1	1	9.30				522.50	732.00
Sweep		tractor 35hp back fork		1		6.00		7.20		
Bin loading/handling	tractor 50hp rear frks frnt ldr & frks	tractor 60hp highlift fork	1	1	5.34	6.00	6.40	7.20		
Custom hauling	47.5 bins	60 bins	1	1					166.25	183.00
Cleanup		tractor 35hp trailer		1		0.50		0.60		
Rodent control	hand labour	custom aerial	1	1			0.40		2.90	20.3
Gopher control		tractor 60hp gopher machine		1		0.25		0.30		5.61
Transp. use of pickup	pickup 1/2 ton	pickup 1/2 ton			8.60	10.00	10.32	12.00		
Misc. use of trailer		tractor 60hp trailer				0.50		0.60		

SOURCES: (a) B.C.M.A.F. "Estimated Costs and Returns: Apple Orchard Establishment and Production." Study No. 266, May 1984.

(b) Compiled from Hinman, H.R.; Hunter, R. E.; and Tukey, R. B. "1985 Cost of Establishing An Apple Orchard Columbia Basin, Washington." College of Agriculture, Washington State University, Pullman, Washington Extension Bulletin 0960, January, 1985.

(c) Labour hours per acre = machine hours per acre × 1.2

(d) The exchange rate, 1984 monthly noon average, is 1.22 Cand per US$.

(e) An estimate provided by Ted H. Van der Gulik, Agricultural Engineer, B.C.M.A.F.

machine hours specified in the B.C.M.A.F. study. With the new estimated machine hours, labour hours are derived by multiplying the machine hours by 1.2 to reflect time required to adjust implements. This is a method employed in the Washington State studies. For hand operations, labour hours are the same as those in the B.C. study.

In the case of Washington State, the operations/practices, machine used, machine hours and service/material cost are compiled from various existing apple orchard studies (Hinman, Hunter, and Tukey, 1981, 1982, 1985) for trees age 1 to 5 and mature. According to these studies, the information was obtained from meetings with experienced fruit growers, extension agents and horticulturalists. Management practices for trees age 6 through 8 are derived from management practices set out for year 5 and mature trees. The machine hours and material/service cost for fertilizer application, cover spray, prepink spray, herbicide application, insecticide application, mowing, irrigation, chemical thinning, and rodent and gopher control are assumed to be the same as for year 5 and mature trees. Adjustments are made to labour and machine hours required to prune and train trees, thin trees, and harvest fruit by applying a constant linear growth rate calculated by taking the difference between year 5 and mature hour requirements and dividing by the number of years between 5 and mature. Pruning time is assumed to peak in year 8; hence, the hours required to prune and train will be

the same for mature and year 8 trees. [15] Bin handling hours and harvesting costs are adjusted according to the increase in the number of bins harvested. Again, labour hours are estimated by multiplying the machine hours by a factor of 1.2.

3.2.2.1 Estimating Ownership and Operating Costs

Aside from land and trees, an orchardist must invest a large amount on capital assets that are required to maintain an orchard. These capital investments will include tractor(s), implements, buildings, vehicles and various other equipment. Consequently, every orchardist incurs some costs associated with these capital investments. Two common categories of asset costs are ownership and operating costs. Ownership costs are costs associated with owning the assets. These include depreciation cost; opportunity/interest cost on investment, insurance cost, property taxes, sales taxes and housing cost. Operating costs are costs associated with utilization of a machine. These include repair and maintenance, fuel

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[15] Conversation with Brooke Peterson, Yakima County Extension Agent, indicated that pruning peaks before full production occurs.

cost, lubricant cost and labour cost associated with operating the machine. An accurate economic estimate of production costs requires the inclusion of both categories of cost.

Having defined a set of capital assets for each orchard previously, it is important to choose a standard method to calculate ownership and operating costs. As indicated in the literature review section, the capital budgeting approach appears to be the most appropriate. The most important categories of ownership cost are depreciation and opportunity cost. To calculate these costs, an estimate of a machine's salvage/remaining value has to be obtained first. For machinery and implements, this is derived using equation (5). A complete set of variable definitions is defined in Appendix B.

$$(5) \qquad SV_i\ (t) = RFV1_i * (RFV2_i)^t * RV_i$$

The annual salvage value of a machine or implement in year t (SV_i (t)) is estimated as a product of its replacement value (RV_i) and an initial salvage factor ($RFV1_i$) multiplied by a second salvage factor taken to the power of the year in which the salvage value is calculated, $(RFV2_i)^t$. One minus the salvage factors, RFV1 and RFV2, are the rates at which a machine or piece of equipment is depreciated in year 1 and thereafter,

respectively. With the exception of tractors, the same factors are used for similar machines in the two representative orchards. These factors are averages published in the Agricultural Engineering Yearbook. They are also used in Washington State's cost of production studies (Hinman, Hunter, and Tukey, 1981, 1982, 1985).

For the B.C. orchard, the tractor is depreciated at an initial rate of 14.2 percent (McNeill) and a linear depreciation rate of 20 percent thereafter. In contrast, the tractors in Washington State are depreciated at the rates of 32 and 8 percent, respectively. The lower depreciation rates applied to the B.C. tractor reflect lower total hours used over the machine's life. Since no common estimated salvage factors exist for depreciating small equipment and buildings, a straight line method, equation (6), has been employed. In most cases, a 10 percent salvage value is assumed at year T, the replacement year (i.e. $SV_i\ (T) = .1 * RV_i$).

$$(6) \qquad SV_i\ (t) = \{RV_i - SV_i\ (T)\} / T$$

To eliminate inflationary factors, current machinery prices are used as replacement values (RV_i). Annual depreciation cost of machine i (D_i) is obtained by multiplying the net present value of the salvage values over the machine's life, $\Sigma_{t=1}^{T}\ (SV_i\ (t-1)-SV_i\ (t)/(1+r)^t$

, by an amortization factor (a(r,T)) which is a function of the discount rate (r) and the replacement year (T).

$$(7) \qquad D_i = \{\sum_{t=1}^{T} (SV_i\ (t-1) - SV_i\ (t)) \ / \ (1+r)^t \ \} \ * \ a(r,T)$$

Opportunity cost (OC_i) is derived in a similar manner

$$(8) \qquad OC_i = \{\sum_{t=1}^{T} r^* SV_i\ (t-1) \ / \ (1+r)^t \ \} \ * \ a(r,T)$$

A real discount rate of 6 percent is used for B.C. (Jenkins) and 5 percent for Washington State. The one percent difference comes from observed differences in market interest rates and inflationary rates.

Annual insurance (I_i), housing (O_i), property taxes and sales taxes ($P_i + S_i$) are calculated using similar equations. In each case, the cost is assumed to be a certain percent of the replacement value (RV_i). To calculate the individual costs, annual costs are discounted and summed over the life of the machine and multiplied by an amortization factor (a(r,T)), as in equations (9) to (11).

$$(9) \qquad I_i = [\Sigma_{t=1}^{T} \{(RV_i * 0.0025) / (1+r)^t\}] * a(r,T)$$

$$(10) \qquad O_i = [\Sigma_{t=1}^{T} \{(RV_i * 0.0075) / (1+r)^t\}] * a(r,T)$$

$$(11) \qquad P_i + S_i = [\Sigma_{t=1}^{T} \{(RV_i * 0.01) / (1+r)^t\}] * a(r,T)$$

The assumed percentages (0.0025, 0.0075, and 0.01 for insurance, housing, and property and sales taxes) are those suggested in the Agricultural Engineering Yearbook. However, since all farm machines are exempted from sales tax in B.C., this cost has not been included. Hence, for B.C., equation (11) reduces to

$$(12) \qquad P_i = [\Sigma_{t=1}^{T} \{(RV_i * 0.005) / (1+r)^t\}] * a(r,T)$$

The percent applied (0.005) is an estimated value.

In keeping with the measurement of time required to complete an operation, all the categories of ownership cost are calculated on a per hour basis. The per hour cost of a machine or implement is obtained by dividing

each annual cost by the hours used per year, h. For small equipment and buildings, the costs are estimated as annual costs.

The main source of operating cost comes from annual repair and maintenance (R&M) of machines and implements. These costs are obtained from the following equation.

$$(13) \qquad R\&M_i\ (t) = \{\sum_{h=1}^{H} (CRC_i\ (H) - CRC_i\ (H-1)) / (1+r)^t \} * a(r,T)$$

where

$$(14) \qquad CRC_i\ (H) = RV_i * RF1_i * RF2_i * (H_i / 1000)^{RF3_i}$$

Annual R&M is estimated by multiplying the net present value of the cumulative repair costs over life of machine or implement, $\Sigma_{h=1}^{H} (CRC_i\ (H)-CRC_i\ (H-1))/(1+r)^t$, by an amortization factor (a(r,T)). Annual cumulative repair and maintenance ($CRC_i\ (H)$) is a function of replacement value (RV_i), the assumed repair rates (RF1, RF2, and RF3) and the cumulative hours of use (H) divided by 1000. Again, the RF1, RF2 and RF3 values are assumed to be the same for similar machines in both regions (i.e. same repair curve). The values used are averages listed in the Agricultural Engineering

Yearbook. For tractors, as shown in equation (15), annual fuel costs ($F1_i$) are obtained by multiplying the number of horsepower of a machine (hp) by a fuel consumption factor (m) and a per unit fuel cost(f).

(15) $$F1_i = hp * m * f$$

For pickups, equation (16) is employed to calculate fuel costs.

(16) $$F2_i = (RV_i / 1000) * m * f$$

Except for machines with power, lubricant costs are included in R&M. Otherwise, annual lubricant costs (L_i) are estimated as 15 percent of fuel cost ($F1_i$).

(17) $$L_i = 0.15 * F1_i$$

Alternatively,

(18) $$L_i = 0.15 * F2_i$$

15 percent is the value suggested by the Agricultural Engineering Yearbook. The sum of equations (9) through (13) provides total annual operating costs for individual machines or implements. No annual operating

costs are estimated for small equipment and buildings. As in the 1985 orchard study (Hinman, Hunter, and Tukey), a labour cost of $7.06 Canadian per hour is applied to Washington State for operations requiring a labourer. A labour cost of $8 per hour is applied to all labour in B.C. Again, the per hour costs are obtained by dividing the annual costs by hours used annually, h.

3.2.3 PRODUCTION COST SCHEDULES

A set of management schedules indicating machine and labour hours required per operation per acre has been established above. In addition, the categories of ownership and operating cost for each capital asset, on a per hour basis, have been calculated. By combining these two sets of established information, a new set of schedules, production cost schedules, is derived. The production cost schedules are presented in Tables 18 to 26. Each production cost schedule indicates the opportunity cost, depreciation cost, insurance cost, housing cost, property and sales taxes, repair and maintenance cost, fuel and lubricant cost, labour cost and service/ material cost per operation per acre and by age of trees. Except for labour and service/material

TABLE 10

PRODUCTION COST SCHEDULE OF TREES IN FIRST YEAR ESTABLISHMENT STAGE, B.C. AND WASHINGTON STATE, PER ACRE

OPERATION	DEPRECIATION COST		OPPORTUNITY COST		INS, PROP, SALES & HOUSING COST		R & M COST		FUEL & LUB COST		LABOUR COST		MATERIAL/ SERVICE COST		TOTAL COST	
	B.C. Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984
Tree & Root Removal											384.00	338.88	250.00	250.00	634.00	588.88
Ground Preparation	292.21		146.72		121.52		1.51		0.50		26.88	5.93		20.74	589.34	26.67
Layout/staking & stakes											64.00	10.59		0.12	64.00	10.71
Plant trees	255.69		122.36		88.45		2.53		0.97		238.08	43.77	1131.00	1476.81	1839.09	1520.58
Hauling plants		6.08		2.64		2.75		0.14		0.13		7.06				18.80
Fertilizer Application											2.16	7.06	5.73	114.44	7.89	121.50
Handseed 5.4kg fescue mix											4.00		30.00		34.00	
Weeding hand hoeing											80.64				80.64	
Stake training & pruning											26.88		7.87		34.75	
Mowing	25.68	46.58	10.13	24.27	7.42	25.88	0.94	1.56	0.29	0.10	15.36	10.59			59.82	108.97
Nutrient Application	11.57		4.40		3.08		0.38		0.14		7.68		24.51		51.76	
Trichlam 6 oz	3.82		1.45		1.02		0.13		0.05		2.53		2.52		11.51	
Acron 25 lbs	4.00		1.64		1.17		0.09		0.04		2.07		12.10		21.12	
Herbicide Application		14.23		7.96		7.79		0.47		0.04		4.66		17.25		52.41
Irrigation & water fee	137.76	330.96	131.04	199.92	26.88	94.08	35.28	69.55	0.00	0.26	12.00	21.18	70.00	34.97	412.96	750.94
House guard											3.20		110.40		113.60	
Rodent control											3.20		2.29	20.37	5.49	20.37
Gopher control		8.03		4.16		4.66		0.18		0.02		1.77		5.61		24.42
Use of pickup	59.77	54.72	31.13	23.76	22.70	24.75	0.74	1.24	9.12	1.20	82.56	63.54			206.02	169.21
Small tools & equipment	23.52	26.99	10.16	5.08	4.90	3.56									38.59	35.63
Pruning tools		0.56		0.07		0.06										0.69
Picking sacks & ladders	18.28	0.31	1.37	0.05	0.72	0.05									20.37	0.41
Machine shed	57.48	23.18	50.79	40.31	10.04	8.87									118.33	72.36
Pickers' cabin	95.79		84.65		16.77										197.21	
Subtotal	985.56	511.63	595.85	308.22	304.69	172.45	41.60	73.14	11.11	1.75	955.25	515.03	1646.42	1940.34	4540.48	3522.56
Tax on land															30.00	26.84
Rent on land															154.88	311.13
Overhead cost															132.72	126.51
Interest on operating capital															159.26	139.16
TOTAL COST PER ACRE															5017.34	4126.21

TABLE 19

PRODUCTION COST SCHEDULE FOR TREES IN YEAR 2 ESTABLISHMENT STAGE, B.C. AND WASHINGTON STATE, PER ACRE

OPERATION	DEPRECIATION COST		OPPORTUNITY COST		INS, PROP, SALES & HOUSING COST		R & M COST		FUEL & LUB COST		LABOUR COST		MATERIAL/ SERVICE COST		TOTAL COST	
	B.C. Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984
Replanting @ 5I & plant pollenizers		21.37		11.97		12.29		0.72		0.07	6.00	22.59	56.56	175.68	62.56	244.69
Haul & water plants		6.00		2.64		2.75		0.14		0.13		8.47				20.21
Pruning & training											53.84	35.30	24.03		77.87	
Disc		2.02		1.76		1.60		0.14		0.01		1.69		6.10		14.14
Seed grass		3.53		2.21		2.01		0.18		0.02		2.12		13.58		23.63
Fert. application	8.00	14.61	3.29	7.02	2.33	7.65	0.23	0.18	0.54	0.02	4.15	2.12	17.23	25.62	35.75	57.21
Nutrient application	11.57		4.40		3.08		0.38		0.14		7.68		24.51		51.76	
Herbicide application	44.06	14.23	15.62	7.96	10.80	7.79	1.58	0.47	0.65	0.04	34.56	5.65	28.21	17.25	135.48	53.40
Aphid control	3.02		1.45		1.02		0.13		0.05		2.53		2.52	20.30	11.51	20.30
Mowing	51.36	46.58	20.26	51.78	14.85	25.88	1.88	1.56	0.58	0.10	30.72	14.40			119.64	140.28
Irrigation & water fee	137.76	330.96	131.04	199.92	26.88	94.08	35.28	69.55	0.00	0.26	12.00	21.18	70.00	34.99	412.96	750.94
Rodent control											3.20		2.29	20.37	5.49	20.37
Gopher control		8.03		4.16		4.66		0.18		0.02		2.12		5.61		24.77
Transp. use of pickup	59.77	54.72	31.13	23.76	22.70	24.75	0.74	1.24	9.12	1.20	82.56	86.40			206.02	192.07
small tools & equipment	23.52	26.99	10.16	5.08	4.90	3.56									38.58	35.63
Pruning tools		0.56		0.07		0.06										0.69
Picking sacks & ladders	3.83	0.31	1.37	0.05	0.72	0.05									5.92	0.41
Machine shed	57.48	23.18	50.79	40.31	10.06	8.87									118.33	72.36
Pickers' cabin	95.79		84.45		16.77										197.21	
Subtotal	496.96	553.96	354.16	358.69	114.11	195.99	40.20	74.36	11.07	1.87	237.24	202.04	225.35	319.51	1479.09	1671.12
Tax on land															30.00	46.36
Rent on land															154.88	311.13
Overhead cost															25.69	29.89
Interest on operating capital															30.83	32.88
TOTAL COST PER ACRE															1720.49	2091.37

TABLE 20

PRODUCTION COST SCHEDULE FOR TREES IN YEAR 3 ESTABLISHMENT STAGE, B.C. AND WASHINGTON STATE, PER ACRE

OPERATION	DEPRECIATION COST		OPPORTUNITY COST		INS, PROP, SALES & HOUSING COST		R & M COST		FUEL & LUB COST		LABOUR COST		MATERIAL/ SERVICE COST		TOTAL COST	
	B.C. Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984
Pruning & training											67.36	109.43	15.91	80.52	83.27	189.95
Fertilizer application	8.00	14.61	3.29	7.02	2.33	7.65	0.19	0.18	0.08	0.02	4.15	2.12	22.90	25.62	40.93	57.21
Dormant oil 2 gal	17.35		6.60		4.62		0.57		0.22		11.52		7.80		48.68	
Fruit removal												7.06				
Nutrient application	28.92		11.00		7.70		0.95		0.36		19.20		53.94		122.07	
Herbicide application	44.06	21.34	15.62	11.94	10.80	11.69	1.52	0.71	0.65	0.07	34.56	8.47	28.21	28.51	135.48	82.73
Aphid control	3.23		1.15		0.79		0.13		0.05		2.53		5.05	22.74	12.93	22.74
Flictran 4 oz	17.35		6.60		4.62		0.57		0.22		11.52		6.05		46.93	
Mowing	51.36	46.58	20.26	24.27	14.85	25.88	1.88	1.56	0.58	0.10	30.72	12.71			119.64	111.08
Irrigation & water fee	137.76	330.96	131.04	199.92	26.88	94.08	35.28	69.55	0.00	0.24	12.00	21.18	70.00	34.99	412.96	750.94
Rodent control											3.20		2.29	20.37	5.49	20.37
Gopher control		8.03		4.16		4.66		0.18		0.02		2.12		5.61		24.77
Transp. use of pickup	59.77	60.80	31.13	26.40	22.70	27.50	0.74	1.38	9.12	1.33	82.56	84.72			206.02	202.13
small tools & equipment	23.52	26.99	10.14	5.08	4.90	3.56									38.58	35.63
Pruning tools		0.56		0.07		0.06									0.00	0.69
Picking sacks & ladders	3.83	0.31	1.37	0.05	0.72	0.05									5.92	0.41
Machine shed	57.48	23.18	50.79	49.31	10.06	8.87									118.33	72.36
Pickers' cabin	95.79		84.65		16.77										197.21	
Subtotal	548.43	533.35	373.66	319.22	127.75	183.99	41.88	73.56	11.26	1.79	279.32	247.81	212.15	218.37	1594.43	1571.03
Tax on land															30.00	46.36
Rent on land															154.88	311.13
Overhead cost															27.23	27.08
Interest on operating capital															32.68	29.78
TOTAL COST PER ACRE															1839.22	1985.38

TABLE 21

PRODUCTION COST SCHEDULE FOR TREES IN YEAR 4 ESTABLISHMENT AND FIRST PARTIAL CROP STAGE, B.C. AND WASHINGTON STATE, PER ACRE

OPERATION	DEPRECIATION COST		OPPORTUNITY COST		INS, PROP, SALES & HOUSING COST		R & M COST		FUEL & LUB COST		LABOUR COST		MATERIAL/ SERVICE COST		TOTAL COST	
	B.C. Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984
Pruning & training											80.80	187.09		80.52	80.80	267.61
Fertilizer application	8.00	12.76	3.29	5.87	2.33	6.60	0.19	0.12	0.08	0.01	4.15	2.12	28.57	25.62	46.60	53.08
Cover spray		26.51		13.67		14.16		0.59		0.05		6.78		29.77		91.53
Prepink spray		13.26		6.84		7.08		0.29		0.03		2.82		21.37		51.69
Fruit thinning											26.96	58.81			26.96	
Nutrient application	52.06		19.80		13.86		1.71		0.65		34.56		37.98		160.62	
Herbicide application	44.04	9.35	15.62	4.91	10.80	5.02	1.58	0.47	0.65	0.04	34.56	5.65	28.21	15.81	135.48	41.26
Insecticide application	121.46	13.26	46.20	6.84	32.34	7.08	4.00	0.29	1.51	0.03	80.64	3.39	137.40	14.29	423.55	45.17
Fungicide application	34.70		13.20		9.24		1.14		0.43		23.04		19.04		100.80	
Boron 25 lbs	4.00		1.64		1.17		0.09		0.04		2.07		12.07		21.09	
Mowing	51.34	46.58	20.26	24.27	14.85	25.88	1.88	1.36	0.58	0.10	30.72	12.71			119.64	111.08
Irrigation & water fee	137.76	330.96	131.04	199.92	26.88	94.08	35.28	69.55	0.00	0.26	12.00	21.18	70.00	34.99	412.96	750.94
Harvesting/picking													33.00	61.49	33.00	61.49
Bin hauling/handling	3.73	7.09	1.46	2.12	1.11	4.03	0.11	0.36	0.04	0.03	2.30	4.24			8.75	17.87
Bin hauling		3.39		2.12		1.93		0.23		0.02		4.24				11.92
Custom hauling													7.00	15.25	7.00	15.25
rodent control													2.29	20.37	5.49	20.37
Gopher control		8.03		4.16		4.66		0.18		0.02	3.20	2.12		5.61		24.77
Transp. use of pickup	59.77	60.80	31.13	26.40	22.70	27.50	0.74	1.38	9.12	1.33	82.56	84.72			206.02	202.13
Misc. use of trailer		19.84		11.55		11.36		0.74		0.07		8.47				52.06
small tools & equipment	23.52	26.99	10.16	5.08	4.90	3.56									38.58	35.63
Pruning tools		0.56		0.07		0.06										0.69
Picking sacks & ladders	3.83	0.31	1.37	0.05	0.72	0.05									5.92	0.41
Machine shed	57.48	23.18	50.79	40.31	10.06	8.87									118.33	72.36
Pickers' cabin	95.79		84.65		16.77										197.21	
Subtotal	697.53	602.87	430.61	354.17	167.73	221.90	46.71	75.77	13.09	1.99	417.56	404.33	375.56	325.09	2148.79	1927.30
Tax on land															30.00	46.36
Rent on land															154.88	311.13
Overhead cost															42.65	40.36
Interest on operating capita															51.18	44.39
TOTAL COST PER ACRE															2427.50	2369.54

TABLE 22

PRODUCTION COST SCHEDULE FOR TREES IN YEAR 5 ESTABLISHMENT AND SECOND PARTIAL CROP STAGE, B.C. AND WASHINGTON STATE, PER ACRE

OPERATION	DEPRECIATION COST		OPPORTUNITY COST		INS, PROP, SALES & HOUSING COST		R & M COST		FUEL & LUB COST		LABOUR COST		MATERIAL/ SERVICE COST		TOTAL COST	
	B.C. Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984
Pruning & training											154.96	257.69		7.32	154.96	265.01
Fertilizer application	8.00	12.76	3.29	5.87	2.33	6.40	0.19	0.12	0.08	0.01	4.15	2.12	28.62	42.70	46.65	70.16
Cover spray		26.51		13.67		14.16		0.59		0.05		6.78		29.77		91.53
Preplnk spray		13.26		6.84		7.08		0.29		0.03		3.39		21.37		52.25
Pollination													36.00	49.41	36.00	49.41
Fruit thinning		26.51		13.67		14.16		0.59		0.05	80.80	6.78		15.81	80.80	77.57
Nutrient application	52.06		19.80		13.86		1.71		0.65		34.56		37.98		160.62	
Herbicide application	44.06	9.35	15.62	4.91	10.80	5.02	1.58	0.47	0.65	0.04	34.56	5.65	28.21	15.81	135.48	41.26
Insecticide application	121.46	13.26	46.20	6.84	32.34	7.08	3.68	0.29	1.51	0.03	80.64	3.39	137.40	17.76	423.24	48.64
Fungicide application	34.70		13.20		9.24		1.05		0.43		23.04		19.04		100.71	
Mowing	171.33	46.58	70.53	24.27	78.14	25.08	30.02	1.56	8.86	0.10	30.72	12.71			389.60	111.00
Irrigation & water fee	137.76	330.96	131.04	199.92	26.88	94.08	35.28	69.55	0.00	0.26	12.00	21.18	70.00	34.99	412.96	750.94
Harvesting/picking													110.00	183.00	110.00	183.00
Bin distribution/ handling	25.99	20.34	10.14	12.69	7.72	11.55	0.75	1.40	0.30	0.10	14.03	25.42			60.92	71.49
Load		54.84		31.89		30.39		2.20		0.20		25.42				144.93
Sweep		20.34		12.69		11.55		1.40		0.10		25.42				71.49
Custom hauling													35.00	45.75	35.00	45.75
Rodent control													2.29	20.37	5.49	20.37
Gopher control		8.03		4.16		4.44		0.18		0.02	3.20			5.61		24.77
Cleanup		6.23		3.47		3.58		0.25		0.02		2.12				17.77
Transp. use of pickup	59.77	3.04	31.13	1.32	22.70	1.38	0.74	1.38	9.12	1.33	82.56	4.24			206.02	93.17
Misc. use of trailer		9.93		5.78		5.68		0.37		0.03		84.72				26.03
small tools & equipment	23.52	26.99	10.14	5.08	4.90	3.56						4.24			38.58	35.63
Pruning tools		0.56		0.07		0.04										0.69
Picking sacks & ladders	3.83	0.31	1.37	0.05	0.72	0.03									5.92	0.41
Machine shed	57.48	23.18	50.79	40.31	10.06	8.87									118.33	72.36
Pickers' cabin	95.79		84.65		16.77										197.21	
Subtotal	835.75	652.96	487.92	393.48	236.47	255.38	74.99	80.63	21.60	2.36	557.22	491.23	504.54	489.68	2718.48	2365.73
Tax on land															30.00	46.36
Rent on land															154.88	311.13
Overhead cost															57.92	53.20
Interest on operating capital															69.50	58.52
TOTAL COST PER ACRE															3030.78	2834.93

TABLE 23

PRODUCTION COST SCHEDULE FOR TREES IN YEAR 6 ESTABLISHMENT AND THIRD PARTIAL CROP STAGE, B.C. AND WASHINGTON STATE, PER ACRE

OPERATION	DEPRECIATION COST		OPPORTUNITY COST		INS, PROP, SALES & HOUSING COST		R & M COST		FUEL & LUB COST		LABOUR COST		MATERIAL/ SERVICE COST		TOTAL COST	
	B.C. Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984
Pruning & training											215.44	375.38		7.32	215.44	382.70
Fertilizer application	8.00	12.76	3.29	5.07	2.33	6.40	0.19	0.12	0.08	0.01	4.15	2.12	34.35	42.70	52.38	70.16
Cover spray		26.51		13.67		14.16		0.59		0.05		4.78		29.77		91.53
Preplnt spray		13.26		6.84		7.08		0.29		0.03		3.39		21.37		52.25
Pollination													36.00	49.41	36.00	49.41
Fruit thinning		26.51		13.67		14.16		0.59		0.05	107.76	6.64		15.81	107.76	77.43
Nutrient application	52.06		19.80		13.86		1.71		0.65		34.56		37.98		160.62	
Herbicide application	44.06	9.35	15.62	4.91	10.80	5.02	1.58	0.31	0.65	0.02	34.56	5.65	28.21	15.81	135.48	41.07
Insecticide application	102.82	13.26	36.46	6.84	25.20	7.08	4.00	0.29	1.51	0.03	80.64	3.39	137.40	17.76	388.02	48.64
Fungicide application	34.70		13.20		9.24		1.14		0.43		23.04		19.04		100.80	
Mowing	51.36	46.58	20.26	24.27	14.85	25.88	1.88	1.08	0.58	0.10	30.72	12.71			119.64	110.60
Irrigation & water fee	137.76	330.96	131.04	199.92	26.88	94.08	35.28	69.55	0.00	0.26	12.00	21.18	70.00	34.99	412.96	750.94
Harvesting/picking													165.00	320.86	165.00	320.86
Bin distribution/ handling	51.81	47.87	20.21	26.44	15.38	26.09	1.49	2.05	0.60	0.14	31.97	37.28			121.47	139.88
Load		80.43		46.77		44.57		2.05		0.14		37.28				211.25
Swamp		29.83		18.61		16.94		3.22		0.29		37.28				106.17
Custom hauling													70.00	80.22	70.00	80.22
Rodent control											3.20		2.90	20.37	6.10	20.37
Gopher control		8.03		4.16		4.66		0.18		0.02		2.12		5.61		24.77
Cleanup		6.23		3.47		3.58		0.25		0.02		4.24				17.77
Transp. use of pickup	59.77	60.80	31.13	26.40	22.70	27.50	0.74	1.38	9.12	1.33	82.56	84.72			206.02	202.13
Misc. use of trailer		9.93		5.78		5.68		0.37		0.03		4.24				26.03
small tools & equipment	23.52	26.99	10.16	5.08	4.90	3.56									38.58	35.63
Pruning tools		0.56		0.07		0.06										0.69
Picking sacks & ladders	18.28	0.31	7.61	0.05	3.72	0.05									29.61	0.41
Machine shed	57.48	23.18	50.79	40.31	10.96	8.87									118.33	72.36
Pickers' cabin	95.79		84.65		16.77										197.21	
Subtotal	737.41	773.34	444.22	453.12	176.70	315.61	48.00	82.32	13.61	2.52	660.60	644.37	600.88	662.01	2681.41	2933.29
Tax on land															30.00	46.36
Rent on land															154.88	311.13
Overhead cost															66.15	69.56
Interest on operating capita															79.38	76.52
TOTAL COST PER ACRE															3011.83	3436.86

TABLE 24

PRODUCTION COST SCHEDULE FOR TREES IN YEAR 7 ESTABLISHMENT AND FOURTH PARTIAL CROP STAGE, B.C. AND WASHINGTON STATE, PER ACRE

OPERATION	DEPRECIATION COST		OPPORTUNITY COST		INS, PROP, SALES & HOUSING COST		R & M COST		FUEL & LUB COST		LABOUR COST		MATERIAL/ SERVICE COST		TOTAL COST	
	B.C. Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984
Pruning & training	44.64		23.36		19.04		15.02		1.12		242.40	493.07		7.32	345.58	500.39
Fertilizer application	8.00	12.76	3.29	5.87	2.33	6.60	8.00	0.12	3.29	0.01	4.15	2.12	34.35	42.70	63.40	70.16
Cover spray		26.51		13.67		14.16		0.59		0.05		6.78		29.77		91.53
Preplnt spray		13.26		6.84		7.08		0.29		0.03		3.39		21.37		52.25
Pollination													36.00	49.41	36.00	49.41
Fruit thinning		26.51		13.67		14.16		0.59		0.05	107.68	6.64		15.81	107.68	77.43
Nutrient application	52.06		19.80		13.84		1.71		0.65		34.56		37.98		160.62	
Herbicide application	44.06	9.35	15.62	4.91	10.80	5.02	1.58	0.47	0.65	0.04	34.56	5.65	28.21	15.81	135.48	41.26
Insecticide application	121.46	13.26	46.20	6.84	32.34	7.08	4.00	0.29	1.51	0.03	80.64	3.39	137.40	17.76	423.55	48.64
Fungicide application	34.70		13.20		9.24		1.14		0.43		23.04		19.04		100.80	
Elgetol .74 gal	17.35		6.60		4.62		0.57		0.22		11.52		27.70		68.58	
Boron 11 kg	4.00		1.64		1.17		0.09		0.04		2.07		12.10		21.12	
Mowing	51.36	46.58	20.26	24.27	14.85	25.88	1.88	1.56	0.58	0.10	30.72	12.71			119.64	111.08
Irrigation & water fee	137.76	330.96	131.04	199.92	26.88	94.08	35.28	69.55	0.00	0.26	12.00	21.18	70.00	34.99	412.96	750.94
Harvesting/picking	15.17		7.94		6.59		5.68		0.45				357.50	457.50	393.32	457.50
Bin distribution/ handling	77.80	34.10	30.35	21.28	23.10	19.37	2.24	2.35	0.90	0.16	48.00	43.32			182.39	120.58
Load		91.95		53.47		50.95		3.61		0.34		43.32				243.64
Swamp		34.10		21.28		19.37		2.42		0.16		43.32				120.65
Custom hauling													113.75	114.38	113.75	114.38
Rodent control											3.20		2.90	20.37	6.10	20.37
Gopher control		8.03		4.16		4.66		0.18		0.02		2.12		5.61		24.77
Cleanup		6.23		3.47		3.58		3.37		2.10		4.24				22.98
Transp. use of pickup	59.77	60.80	31.13	26.40	22.70	27.50	0.74	1.38	9.12	1.33	82.56	84.72			206.02	207.13
Misc. use of trailer		9.93		5.78		5.68		0.37		0.03		4.24				26.03
small tools & equipment	23.52	26.99	10.16	5.88	4.90	3.56									38.58	35.63
Pruning tools		0.56		0.07		0.06										0.69
Picking sacks & ladders	18.28	0.31	7.61	0.05	3.72	0.05									29.61	0.41
Hacking shed	57.48	23.18	50.79	40.31	10.06	8.87									118.33	72.36
Pickers' cabin	95.79		84.65		16.77										197.21	
Subtotal	863.20	775.35	503.64	457.32	222.97	317.70	77.91	87.14	18.94	4.71	717.10	780.20	876.93	832.81	3280.70	3255.23
Tax on land															30.00	46.36
Rent on land															154.88	311.13
Overhead cost															84.54	85.24
Interest on operating capital															101.45	93.77
TOTAL COST PER ACRE															3651.58	3791.73

TABLE 25

PRODUCTION COST SCHEDULE FOR TREES IN YEAR 8 ESTABLISHMENT AND FIFTH PARTIAL CROP STAGE, B.C. AND WASHINGTON STATE, PER ACRE

OPERATION	DEPRECIATION COST		OPPORTUNITY COST		INS, PROP, SALES & HOUSING COST		R & M COST		FUEL & LUB COST		LABOUR COST		MATERIAL/ SERVICE COST		TOTAL COST	
	B.C. Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984
Pruning & training	49.60		25.95		21.15		16.68		1.24		269.36	610.69		7.32	383.99	618.01
Fertilizer application	8.00	12.76	3.29	5.87	2.33	6.60	0.19	0.12	0.08	0.01	4.15	2.12	34.35	42.70	52.38	70.16
Cover spray		26.51		13.67		14.16		0.59		0.05		6.78		29.77		91.53
Preplnt spray		13.26		6.84		7.08		0.29		0.03		3.39		21.37		52.25
pollination													36.00	49.41	36.00	49.41
Thin spray (growth reg)	17.35	26.51	6.60	13.67	4.62	14.16	0.57	0.59	0.22	0.05	11.52	6.64	44.82	15.81	85.70	77.43
Hand thinning											272.00	326.81			272.00	326.81
Nutrient application	52.06		19.80		13.86		1.71		0.65		34.56		37.98		160.62	
Herbicide application	44.06	8.45	15.62	4.51	10.80	4.34	1.58	0.31	0.65	0.02	34.56	5.65	28.21	15.81	135.48	39.09
Insecticide application	121.46	13.26	46.20	6.84	32.34	7.08	4.00	0.29	1.51	0.03	80.64	3.39	137.40	17.76	423.55	48.64
Fungicide application	34.70		13.20		9.24		1.14		0.43		23.04		19.04		100.80	
Mowing	51.36	46.58	20.26	24.27	14.85	25.88	1.88	1.56	0.58	0.10	30.72	12.71			119.64	111.08
Irrigation & water fee	137.76	330.96	131.04	199.92	26.88	94.08	35.28	69.55	0.00	0.26	12.00	21.18	70.00	34.99	412.96	750.94
Bin distribution		37.97		23.69		21.56		2.67		0.18		47.44				133.51
Harvesting/picking	18.96		9.92		8.24		7.19		0.56				440.00	595.36	484.78	595.36
Sweep		37.97		23.69		21.56		2.62		0.18		47.44				133.45
Bin loading/handling	83.03	102.37	32.39	59.53	24.65	56.73	2.39	4.10	0.96	0.37	51.23	47.44			194.64	270.54
Custom hauling													140.00	148.84	140.00	148.84
Cleanup		6.23		3.47		3.58		0.37		0.03		4.24				17.91
Rodent control											3.20		2.90	20.37	6.10	20.37
Gopher control		8.03		4.16		4.66		0.12		0.01		2.12		5.61		24.70
Transp. use of pickup	59.77	60.80	31.13	26.40	22.70	27.50	0.74	7.18	9.12	0.67	82.56	84.72			206.02	207.27
Misc. use of trailer		9.93		5.78		5.68		0.37		0.03		4.24				26.03
small tools & equipment	23.52	26.99	10.16	5.08	4.90	3.56									38.58	35.63
Pruning tools		0.56		0.07		0.06										0.69
Picking sacks & ladders	18.28	0.31	7.61	0.05	3.72	0.05									29.61	0.41
Machine shed	57.48	23.18	50.79	40.31	10.06	8.87									118.33	72.36
Pickers' cabin	95.79		84.65		16.77										197.21	
Subtotal	873.18	792.61	508.61	467.80	227.12	327.17	73.25	90.72	15.99	2.02	909.53	1236.98	990.70	1005.13	3598.38	3922.43
Tax on land															30.00	46.36
Rent on land															154.88	311.13
Overhead cost															99.47	116.74
Interest on operating capita															119.37	128.42
TOTAL COST PER ACRE															4002.10	4525.08

TABLE 26

PRODUCTION COST SCHEDULE FOR MATURE TREES, B.C. AND WASHINGTON STATE, PER ACRE

OPERATION	DEPRECIATION COST		OPPORTUNITY COST		INS, PROP, SALES & HOUSING COST		R & M COST		FUEL & LUB COST		LABOUR COST		MATERIAL/ SERVICE COST		TOTAL COST	
	B.C. Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984	B.C Can $ 1984	WASH. Can $ 1984	B.C. Can $ 1984	WASH. Can $ 1984
Pruning & training	49.60		25.95		21.15		16.48		1.24		269.36	610.69		7.32	383.99	618.01
Fertilizer application	8.00	12.76	3.29	5.87	2.33	4.60	0.19	0.12	0.08	0.01	4.15	2.12	34.35	42.70	52.38	70.16
Cover spray		26.51		13.67		14.16		0.59		0.05		6.78		29.77		91.53
Preplnt spray		13.26		6.84		7.08		0.29		0.03		3.39		21.37		52.25
pollination													36.00	49.41	36.00	49.41
Thin spray (growth reg)	17.35	26.51	6.60	13.67	4.62	14.16	0.57	0.59	0.22	0.05	11.52	6.64	44.82	15.81	85.70	77.43
Hand thinning											272.00	326.81			272.00	326.81
Nutrient application	52.06		19.80		13.86		1.71		0.65		34.56		37.98		160.62	
Herbicide application	44.06	8.45	15.62	4.51	10.80	4.34	1.58	0.31	0.65	0.02	34.56	5.65	28.21	15.81	135.48	39.09
Insecticide application	121.46	13.26	46.20	6.84	32.34	7.08	4.00	0.29	1.51	0.03	80.64	3.39	137.40	17.76	423.55	48.64
Fungicide application	34.70		13.20		9.24		1.14		0.43		23.04		19.04		100.80	
Boron 25 lbs every 3rd yr	1.48		0.61		0.43		0.03		0.01		0.77		4.03		7.37	
Mowing	51.36	46.58	20.26	24.27	14.85	25.88	1.88	1.56	0.58	0.10	30.72	12.71			119.64	111.08
Irrigation & water fee	137.76	330.96	131.04	199.92	26.88	94.08	35.28	69.55	0.00	0.26	12.00	21.18	70.00	34.99	412.96	750.94
Bin distribution		40.68		25.38		23.10		2.87		0.19		50.83				143.05
Harvesting/picking	22.04		11.53		9.58		8.25		0.65				522.50	732.00	574.55	732.00
Sweep		40.68		25.38		23.10		2.80		0.19		50.83				142.99
Bin loading/handling	83.03	109.68	32.39	63.78	24.65	60.78	2.39	4.39	0.96	0.40	51.23	50.83			194.64	289.86
Custom hauling													166.25	183.00	166.25	183.00
Cleanup		6.23		3.47		3.58		0.37		0.03		4.24				17.91
Rodent control											3.20		2.90	20.37	6.10	20.37
Gopher control		8.03		4.16		4.44		0.12		0.01		2.12		5.41		24.70
Transp. use of pickup	59.77	60.80	31.13	26.40	22.70	27.50	0.74	7.18	9.12	0.67	82.56	84.72			206.02	207.27
Misc. use of trailer		9.93		5.78		5.68		0.37		0.03		4.24				26.03
small tools & equipment	23.52	26.99	10.16	5.08	4.90	3.56									38.58	35.63
Pruning tools		0.56		0.07		0.06										0.69
Picking sacks & ladders	18.28	0.31	7.61	0.05	3.72	0.05									29.61	0.41
Machine shed	57.48	23.18	50.79	40.31	10.06	8.87									118.33	72.36
Pickers' cabin	95.79		84.65		16.77										197.21	
Subtotal	877.74	805.34	510.83	475.44	228.89	334.30	74.44	91.39	16.10	2.07	910.30	1247.15	1103.48	1175.53	3721.78	4131.63
Tax on land															30.00	46.36
Rent on land															154.88	311.13
Overhead cost															105.22	125.83
Interest on operating capital															126.26	138.41
TOTAL COST PER ACRE															4138.13	4753.36

cost, each separate category of cost is derived by multiplying the machine hours required to complete an operation (from the management schedules) by the respective costs associated with the machine used. If more than one machine is used, the total cost of any one category of cost is equal to the sum of the costs associated with all machines used. For example, the total depreciation cost associated with the operation fertilizer application is equal to the depreciation cost per hour of the tractor used plus the depreciation cost of the fertilizer spreader per hour multiplied by the number of machine hours required to complete the operation. It should be noted that the fuel and lubricant costs are zero for B.C.'s irrigation system. This results from the assumption that water is supplied through a pressurized system that does not require a pump.

Labour hours required multiplied by wage rate provides a labour cost per operation. Service/material costs are those defined in the management schedules. Other costs included are annual depreciation cost, opportunity cost, insurance cost, housing cost, property and sales taxes on small equipment and buildings. In addition, a tax on land, opportunity cost or rent on land, crop insurance cost, an overhead charge (5 percent of total operating cost) and an interest charge on operating capital have been included. Interest charges on operating capital (IC) are obtained by multiplying total operating cost (σ) by the product of one-half a year (6 months/12 months) and the market discount

rate (d). One half a year is used to reflect the assumption that an operating loan will average 6 months in duration.

(19) $IC = \sigma * (6/12 * d)$

The market interest rates used are 12 and 11.5 percent for B.C. and Washington State, respectively. These interest rates represent the 1984 average prime rates plus one in the respective regions. The five percent of total operating cost is a standard approach taken by cost of production researchers in calculating an overhead charge (B.C.M.A.F., Hinman, Hunter, and Tukey).

Two costs associated with land, i.e. property tax and rental cost, have been included. The rental cost represents an opportunity cost of farming the land. Property taxes are assumed to be $30 per acre for the orchard in B.C. This is the average value used in the B.C.M.A.F. model. The property taxes estimated for Washington State are $26.84 Canadian for one year old trees and $46.36 Canadian for all other trees. The lower tax on new trees is a result of the method employed in calculating property taxes. The value of an orchard is estimated by summing the value of the bare land, the trees and the irrigation system.[16]

Accurate estimates of a rental value for orchard land are very difficult to obtain, since the rental markets are very small in both areas. Annual per acre rents on orchard

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[16]Information obtained from County Tax offices in Washington State.

land vary widely. The most common type of rental arrangement, in B.C. and Washington State, is crop-sharing. In B.C., the average crop-sharing arrangement is based on a 20 to 80 split on gross market returns (ie 20 percent of gross market returns go to the orchard owner as rent and 80 percent of gross market returns go to the operator) The arrangements vary, depending largely on who pays the property taxes, the quality of the land and the trees, and other factors. In B.C., most orchards are rented through private owners or financial institutions.

In contrast, the rental market in Washington State is dominated largely by leases from the State. Orchard leases are written for 25 years and are based on crop-sharing also. Renters are required to bid for their crop-sharing arrangements at public auctions. The average bid accepted for bare land (land without trees and little or no irrigation) is about 7 percent.[17] This implies that, on average, 7 percent of the renter's gross market return goes to pay for the rental of the orchard. Again, the accepted bids will vary according to the availability of water, quality of land and other factors.

For this study, the rental value of land is estimated as 7 percent of gross market returns for Washington State. The 7 percent is employed for Washington State because the producer is assumed to be responsible for all other costs,

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[17]Harold Veeman, Assistant Area Manager South-East Area, Department of Natural Resources, Ellensburg, Washington State.

such as irrigation systems, associated with establishing the orchard initially. Using an average price (1976-83) of 12 [18] Canadian cents per pound and an average yield of 36961 pounds per acre for Washington State, a rental value of $311.13 per acre is thus estimated for this study.

The 20 to 80 split of gross market returns in B.C. includes the rental of land, irrigation system, and trees. By assuming tree replacement is on an on-going process, the tenant pays for the trees in the on-going annual operations. Consequently, the rental value obtained by taking 20 percent of gross market returns includes a rental fee for the irrigation system and land. Since the irrigation system is assumed to be among the assets owned by the operator, the rental value of this equipment has to be subtracted from the calculated rental value on land. Hence, the rental value for bare orchard land is estimated as 20 percent of gross market returns less the depreciation, opportunity, and insurance and property costs of the irrigation system. Using an average market price (1976-83) of 8 cents [19] per pound and an average yield of 27920 pounds per acre, the estimated rent on orchard land is $154.88 per acre for B.C. [20] The

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[18] Derived from the average producer returns shown in Table 3.

[19] Calculated from the average producer returns shown in Table 3.

[20] Employing the same approach, a second rental value is estimated for Washington State (i.e. total rent on orchard land = .2 * gross market returns - (depreciation, opportunity, and insurance and propoerty costs of irrigation system)). In this instance, the estimated rent on orchard land is $358 per acre. This estimate is not used in the study because the 20 percent of gross market return is considered to be higher than what may actually exist in

payment of property tax and water fees is assumed to be the responsibility of the operator.

The sum of total cost per operation plus all other annual costs provide a total production cost per acre by age of trees. These schedules provide per acre, by age of trees, production cost comparisons between the two regions. If differences exist, the tables allow for comparisons on a per operation basis. An average per acre production cost (AC) is derived by summing the product of total cost per acre (C(g)) and the number of acres of trees of the same age(b(g)). This sum is then divided by total acreage of the orchard block (B).

$$(21) \qquad AC = \{\Sigma_{g=1}^{G} (C(g) * b(g))\} / B$$

This provides an average production cost per acre comparison between B.C. and Washington State. Furthermore, a cost per pound can be derived by dividing the average cost per acre (AC) by the average yield per acre (AY).

(22) AC ($/acre) / AY (lb/acre) = cost per lb of apples

The average (average of individual orchard blocks) yield estimated for B.C and Washington State are 27920 and 37039 pounds per acre, respectively. The average yield (AY) is

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[20](cont'd) Washington State. The value obtained in this calculation provides an upper bound on Washington State's land rent.

estimated by summing the product of the yields per acre (y(g)) and the number of acres of trees of the same age (b(g)), equation (23). This sum is then divided by total acres defined for the individual orchard blocks.

$$(23) \qquad AY = [[\Sigma_{g=1}^{G} (y(g) * b(g))] / B]$$

The yields per acre by age of trees (y(g)), as shown in Table 27, are stimated through input obtained from horticulturists and field representatives in both B.C. and Washington State.

The average per acre yields of the four, five and six year old trees for the 20 (202 trees) and 40 (269 trees) acre orchard blocks in B.C. are those used in the B.C.M.A.F. model. For the remaining trees, the average per acre yields are adjusted from information provided by Tim Watson, District Horticulturist, B.C.M.A.F., Oliver and Mike Sanders, Tree Fruit Specialist, B.C.M.A.F., Kelowna. The average per acre yields of the four and five year old trees in Washington State are compiled from the most recent apple production study (Hinman, H.R.; Hunter, R.B.; and Tukey, R.B., 1985). The average per acre yield of the mature trees is based on an existing apple production study (Hinman, Hunter, and Tukey, 1982) and information obtained from county extension agents in Washington State. For the six to

TABLE 27

AVERAGE PER ACRE YIELDS: B.C. VS WASHINGTON STATE
(POUNDS)

AGE OF TREES	B.C.[a] 20 ACRE BLOCK (202 TREES)	WASH.[b] 46 ACRE BLOCK (269 TREES)	B.C.[a] 40 ACRE BLOCK (202 TREES)	WASH.[b] 40 ACRE BLOCK (269 TREES)
1				
2				
3				
4	1600	4125	1600	4125
5	4000	12375	4000	12375
6	10000	21698	10000	21698
7	26000	30938	26000	30938
8	32000	40260	32000	40260
mature	38000	49500	38000	49500
AVERAGE PER ACRE	27920	37039	27920	36961

[a] B.C.M.A.F. "Estimated Costs And Returns: Apple Orchard Establishment And Production." May 1984.
Mike Sanders, Tree Fruit Specialist, B.C.M.A.F., Kelowna.
Tim Watson, Distric Horticulturist, B.C.M.A.F., Oliver.

[b] Hinman, H. R.; Hunter, R.; and Tukey, R. B. "1985 Cost Of Establishing An Apple Orchard Columbia Basin, Washington." College of Agriculture, Washington State University, January 1985.
Hinman, H. R.; Tukey, R. B.; and Hunter, R. E. "Estimated Cost Of Production For A Red Delicious Apple Orchard In Central Washington."
College of Agriculture, Washington State University, June 1982.
Ray Hunter, Douglas County Extension Agent, Washington State.
Brooke Peterson, Yakima County Extension Agent, Washington State.

eight year old trees, a linear growth rate[21] has been assumed since no other data are available. The linear growth rate is estimated by taking the difference between the per acre yields of the mature and five year old trees and dividing by the difference of the tree ages.

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[21] Information provided by Ray Hunter, Douglas County Extension Agent, and Brooke Peterson, Yakima County Extension Agent, in Washington State.

4. CHAPTER IV

4.1 RESULTS

The results obtained are presented in three sections. Section one analyses the results obtained from the production schedules. It compares the per acre production cost by age of trees in B.C. with that of Washington State. Section two presents and examines the average per pound and average per acre production cost estimated for individual orchard blocks in B.C. and Washington State. The final section examines results obtained from various sensitivity analyses.

4.2 RESULTS FROM PRODUCTION SCHEDULES

The total costs per acre by age of trees are summarized in Table 28 for B.C. and Washington State. The per acre cost differentials are also shown in this Table. In B.C., the highest per acre cost, $5017, is obtained from the one year old trees. This is followed by the mature trees with a total per acre cost of $4138. These results show that on a per

TABLE 28

TOTAL COST PER ACRE BY AGE OF TREES: B.C. VS WASHINGTON STATE, IN 1984 CANADIAN DOLLARS

AGE OF TREES	TOTAL COST PER ACRE B. C.	WASH.	B.C.- WASH.
1	5017	4126	891
2	1720	2091	(371)
3	1839	1985	(146)
4	2427	2370	57
5	3031	2835	196
6	3012	3437	(425)
7	3652	3792	(140)
8	4002	4525	(523)
mature	4138	4753	(615)

acre basis, the costs associated with replanting are higher than the costs asscciated with keeping mature trees in production by $879. The differential represents approximately 18 percent of the per acre cost of the one year old trees. The costs associated with replanted areas are even greater if the per acre income foregone is added to the current per acre cost. These results may partly explain why expansion and/or renovation have been retarded in B.C., in the short-run. In the long-run, the decision to expand and/or renovate will be determined primarily by the net present value estimation (i.e. sum of discounted net returns over the life span of the investment) of the project.

In contrast, the mature trees show the highest total per acre cost, $4753, in Washington State. The total per acre cost of the one year old trees rank the third highest, behind the eight year old trees. The costs associated with replanting one acre of trees are less than the costs associated with keeping one acre of trees in production by $627. With the exception of the two and three year old trees, the per acre costs of the remaining trees increase with tree age. Given the management practices set out in the production schedules, these results appear reasonable. For example, the costs associated with harvesting and pruning increase with the age of trees; hence, the total per acre cost should increase with tree age.

With the exception of one, four and five year old trees, the per acre costs by age of trees are lower in B.C.

than in Washington State. The lower per acre costs range from a high of $615 (mature trees) to a low of $140 (seven year old trees). The production schedule, Table 26, indicates that lower total per acre labour cost, material/service cost, and rent on land in B.C. are largely responsible for the cost differential shown by the mature trees. These values are shown in the subtotal row and in the respective columns of the production schedule. The sum of these costs represents $566[22] or 92 percent of the cost differential. Out of $566, $377 is attributed to labour costs. This is a result of lower pruning and training cost in B.C.

The cost differential of the eight year old trees is also largely attributed to lower total per acre labour cost, material/service cost, and rent on land. Lower per acre rent on land in B.C. is responsible for the cost differential shown by the seven and three year old trees. For the six year old trees, the lower per acre cost in B.C. is mainly a result of lower total per acre rents on land, material/service cost, repair and maintenance cost, and insurance, property, sales and housing cost. The lower per acre cost shown by the two year old trees in B.C. is primarily caused by the lower total per acre rent on land, material/service, depreciation, and insurance, property, sales and housing cost.

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[22] This value is obtained as follows:

(1247-910)+(1176-1103)+(311-155)=566

The total per acre cost of the one, four and five year old trees are higher in B.C. than in Washington State. The highest cost differential, $891, is shown by the one year old trees. Examination of the production schedule for the one year old trees (Table 18) indicates that the major contributors to the large cost differential are the total per acre depreciation and opportunity cost of machines used. The total depreciation and opportunity cost per acre for these trees are $986 and $596 for B.C. The same respective values for Washington State are $512 and $308. When summed together, the total cost of depreciation and opportunity cost is shown to be $762 higher in B.C. than in Washington State. This accounts for 85 percent of the total cost differential. The total labour cost in B.C. for the one year old trees is $440 greater than Washington State. However, this higher cost is largely balanced by a lower total per acre rent on land and material/service cost.

A high proportion of the opportunity and depreciation cost in B.C. comes from the ownership of a tree auger and rotovator. In Washington State, it is assumed that orchardists would rent a planter to plant trees; thus, neither the auger or rotovator is among the list of assets owned. By renting a planter, orchardists in Washington State are able to eliminate the cost of owning and maintaining these two implements.[23] In addition, the planter reduces the

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[23]From consultations with field representatives and horticulturists, this appears to be a behaviour difference between B.C. and Washington State orchardists.

labour requirement; hence, a lower labour cost results. In contrast, the cost of owning and operating the auger and rotovator add a total of $609 to the per acre cost of one year old trees. To reduce costs, it may be beneficial for orchardists in B.C. to rent these two implements when needed rather than purchasing them. For example, if an orchardist had rented the tree auger, he would have had a total rental fee of $52 (5.4 hours x $10/hour) [24] per acre as opposed to $261 for the cost of owning and maintaining the auger. By renting the auger, an orchardist in B.C. can potentially reduce the cost differential by 23 percent.

4.3 ESTIMATED PER ACRE AND PER POUND COST OF PRODUCING APPLES

The total average cost (average of individual representative orchard blocks) per acre and per pound are summarized in Table 29. The total average cost per acre and per pound are estimated using equations (21) and (22), respectively. The cost of the individual categories that make up the total cost and their shares, in terms of percentages, of total per acre cost are also provided in

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[24] The rate assumed is $10 per hour as stated by the packinghouse in Oliver.

TABLE 29

COMPARING PRODUCTION COSTS: B.C. VS WASHINGTON STATE, IN 1984 CANADIAN DOLLARS

	AVERAGE COST PER ACRE				AVERAGE COST PER POUND	
	B.C. ($)	(%)	WASH. ($)	(%)	B.C. ($)	WASH. ($)
DEPRECIATION	835	22.1	751	17.9	0.030	0.020
OPPORTUNITY	494	13.1	445	10.6	0.018	0.012
INS, PROP, SALES	218	5.8	305	7.3	0.008	0.008
REPAIR & MAINTENANCE	68	1.8	87	2.1	0.002	0.002
FUEL & LUBRICANT	16	0.5	2	0.1	0.001	0.000
LABOUR	799	21.2	1010	24.1	0.029	0.027
MATERIAL/SERVICE	956	25.3	1019	24.3	0.034	0.028
TAX & RENT ON LAND	185	4.9	357	8.5	0.007	0.010
OVERHEAD & INT. ON OPERATING COST	202	5.4	222	5.3	0.007	0.006
TOTAL COST PER ACRE	3773	100.0	4198	100.0	0.136	0.113

this Table. From the representative orchards, the estimated total average per acre cost is $3773 for B.C. and $4198 for Washington State. B.C.'s per acre cost is $425 lower than Washington State.

In B.C., the four highest categories of cost, in decreasing importance, are material/service, depreciation, labour and opportunity costs. Since the category material/service cost includes input costs such as fertilizers, herbicides, fungicides, nutrients, pesticides, water fees, rodenticides and custom services, it is not surprising that these costs constitute the highest cost, 25 percent of total costs. Although B.C. producers believe labour costs dominate their cost expenditures, results indicate labour costs to be much less, 21 percent of total cost, than expected. The fixed costs, opportunity and depreciation, make up $1329 or 35 percent of total costs. This suggests that more than one-third of total per acre cost is a result of capital investments.

In Washington State, the four highest categories of cost, in decreasing importance, are material/service, labour, depreciation and opportunity cost. The costs associated with inputs and custom services are $1019 which represents 24 percent of total per acre cost. Labour cost is $1010 or 24 percent of total per acre cost. Together, the two costs contribute a sum of 48 percent to total per acre cost. This is a 2 percent higher contribution than the same categories in B.C. In this case, 28 percent of total per

acre cost is attributed to depreciation and opportunity cost which is 7 percent lower than in B.C. This is significant when 7 percent of $3773 is $264. For the B.C. orchard, the per acre cost of tax and rent on land represent only 5 percent of total per acre cost while the same cost in Washington State is about 9 percent of total cost. This is largely due to higher rents on land in Washington State.

The average per pound cost is 13.6 and 11.3 cents for B.C. and Washington State, respectively. B.C.'s per pound cost is 2.3 cents (20 percent) higher than Washington State's. With an average market price of eight cents per pound, this implies that B.C. producers are losing 5.6 cents per pound of apples produced. If the result is true, then why are apple producers in B.C. continuing to produce? Economic theory of a competitive industry suggests that producers will continue to maintain production in the short-run as long as the market returns are equal or greater than the variable costs. From the results estimated, the sum of the variable costs (repair and maintenance, fuel and lubricant, labour, material/service, and overhead and interest on operating costs) constitute 7.3 cents of the total 13.6 cents per pound. At an average market price of 8 cents per pound of apples, this is 0.7 cents above the calculated variable costs.

The primary explanation for the 2.3 cents per pound differential between B.C. and Washington State revolves around the average per acre yield estimated for the

respective regions. Washington State's average (average of the orchard block) per acre yield is 9119 pounds greater than B.C.'s. Despite a lower average (average of orchard block) per acre cost, the lower average per acre yield caused the average total per pound cost to be higher in B.C. than in Washington State.

To examine the issue of efficiency, a ratio based on total output values/total input values per acre is calculated for B.C. and Washington State. The ratio is 0.59 (based on a market price of 8 cents per pound) and 1.06 (based on 12 cents per pound) for B.C. and Washington State, respectively. These ratios suggest that apple producers in Washington State are extracting more returns from their expenditures than the B.C. producers. The producers in Washington State are obtaining returns almost twice as much as the B.C. producers.

4.4 RESULTS FROM SCENARIOS

The results presented in the above sections are based on representative orchard blocks that differ in total acres and planting density. To obtain a better understanding of production costs, several scenarios are examined. Each

scenario is designed to answer a specific question. The objective of these analyses is to determine how production costs change under different assumptions. Three scenarios - input price, acreage and density - are setup for this purpose. The results are examined below.

4.4.1 INPUT PRICE SCENARIO

Differences in input prices have been recognized as a major contributor to overall production costs. The determination of how important a role input prices play in cost differences is the objective of this scenario. In this scenario, the size of orchard blocks and its land composition, management schedules, machinery, and building replacement costs are those defined for the original or base case. However, prices of trees, fuel, labour, water, land tax and rent, and harvesting costs have been exchanged for the two regions. For example, the per unit cost of fuel in B.C. is used to calculate the fuel and lubricant cost of machines in Washington State. With the exception of rent on orchard land, the prices of all other inputs exchanged are higher in B.C. It is suspected that B.C.'s production costs will decline from those obtained in the base case while

Washington State's costs will increase.

The average total per acre costs and per pound costs for all scenarios are summarized in Tables 30 and 31, respectively. With exchanged input prices, the total cost per acre is $3823 for B.C. and $4181 for Washington State. Compared to the base case, this represents an increase of $50 or 1.3 percent per acre for B.C. The increase in the average total per acre cost contradicts what is expected. An examination of the costs by categories show that total labour, fuel and lubricant, material/service costs did decrease, but the increase in the land costs outweiged the decrease in the other categories.

Similarly, a decline in land costs is also responsible for the overall decline in the per acre cost in Washington State. In this case, the total per acre cost declined by $17. On a per pound basis, B.C.'s cost has increased by 0.1 cent while Washington State's has decreased by an equal amount. The efficiency ratio in B.C. declines from 0.59 to 0.58. The increase in the efficiency ratio is too small to be significant for Washington State.

If the rental values of the orchard lands are not exchanged, then the average total per acre cost decreases by $105 in B.C. The average total per acre cost, in Washington State, increases by $138. The average cost of producing one pound of apples for B.C. and Washington State would be 13.1 and 11.7 cents, respectively.

TABLE 30

PRODUCTION COSTS PER ACRE: B.C. VS WASHINGTON STATE, IN 1984 CANADIAN DOLLARS

	BASE CASE		SCENARIOS INPUT PRICE[a] (CASE 1)		ACREAGE[b] (CASE 2)		DENSITY[c] (CASE 3)	
	B.C.	WASH.	B.C.	WASH.	B.C.	WASH.	B.C.	WASH.
DEPRECIATION COST	835	751	835	751	501	806	881	751
	22.1	17.9	21.8	18.0	15.5	18.7	20.6	17.9
OPPORTUNITY COST	494	445	494	445	329	478	513	445
	13.1	10.6	12.9	10.6	10.2	11.1	12.0	10.6
INS, PROP, SALES & HOUSING	218	305	218	305	188	332	233	305
	5.8	7.3	5.7	7.3	5.8	7.7	5.5	7.3
REPAIR & MAINTENANCE	68	87	68	87	72	78	73	87
	1.8	2.1	1.8	2.1	2.2	1.8	1.7	2.1
FUEL & LUBRICANT	16	2	7	3	8	3	16	2
	0.5	0.1	0.2	0.1	0.2	0.1	0.4	0.1
LABOUR COST	799	1010	705	1144	799	1008	904	1010
	21.2	24.1	18.4	27.4	24.7	23.4	21.2	24.1
MATERIAL/SERVICE	956	1019	949	1024	957	1018	1151	1019
	25.3	24.3	24.8	24.5	29.5	23.7	27.0	24.3
TAX & RENT ON LAND	185	357	357	185	185	356	256	357
	4.9	8.5	9.3	4.4	5.7	8.3	6.0	8.5
OVERHEAD & INT. ON OPERATING COST	202	222	190	237	202	221	236	222
	5.4	5.3	5.0	5.7	6.2	5.1	5.5	5.3
TOTAL AVERAGE COST	3773	4198	3823	4181	3241	4300	4263	4198
TOTAL PERCENT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

a Land tax and rent, labour, water fee, fuel, and tree prices in B.C. are equated to Washington State.
The same procedure is applied to the orchard in Washington State.

b B.C. and Washington's orchard blocks have been increased/decreased to 40 acres.

c Density of B.C.'s orchard has been increased from 202 trees per acre to 269 trees per acre.

TABLE 31

PRODUCTION COSTS PER POUND: B.C. VS WASHINGTON STATE, IN 1984 CANADIAN DOLLARS

	BASE CASE		SCENARIOS INPUT PRICE[a] (CASE 1)		ACREAGE[b] (CASE 2)		DENSITY[c] (CASE 3)	
	B.C.	WASH.	B.C.	WASH.	B.C.	WASH.	B.C.	WASH.
DEPRECIATION COST	0.030	0.020	0.030	0.020	0.018	0.022	0.029	0.020
	22.1	17.9	21.8	18.0	15.5	18.7	20.6	17.9
OPPORTUNITY COST	0.018	0.012	0.018	0.012	0.012	0.013	0.017	0.012
	13.1	10.6	12.9	10.6	10.2	11.1	12.0	10.6
INS, PROP, SALES & HOUSING	0.008	0.008	0.008	0.008	0.007	0.009	0.008	0.008
	5.8	7.3	5.7	7.3	5.8	7.7	5.5	7.3
REPAIR & MAINTENANCE	0.002	0.002	0.002	0.002	0.003	0.002	0.002	0.002
	1.8	2.1	1.8	2.1	2.2	1.8	1.7	2.1
FUEL & LUBRICANT	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.5	0.1	0.2	0.1	0.2	0.1	0.4	0.1
LABOUR COST	0.029	0.027	0.025	0.031	0.029	0.027	0.029	0.027
	21.2	24.1	18.4	27.4	24.7	23.4	21.2	24.1
MATERIAL/SERVICE	0.034	0.028	0.034	0.028	0.034	0.028	0.037	0.028
	25.3	24.3	24.8	24.5	29.5	23.7	27.0	24.3
TAX & RENT ON LAND	0.007	0.010	0.013	0.005	0.007	0.010	0.008	0.010
	4.9	8.5	9.3	4.4	5.7	8.3	6.0	8.5
OVERHEAD & INT. ON OPERATING COST	0.007	0.006	0.007	0.006	0.007	0.006	0.008	0.006
	5.4	5.3	5.0	5.7	6.2	5.1	5.5	5.3
TOTAL AVERAGE COST	0.136	0.113	0.137	0.112	0.117	0.117	0.138	0.113
TOTAL PERCENT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[a] Land tax and rent, labour, water fee, fuel, and tree prices in B.C. are equated to Washington State.
The same procedure is applied to the orchard in Washington State.

[b] B.C. and Washington State's orchard blocks have been increased/decreased to 40 acres.

[c] Density of B.C.'s orchard has been increased from 202 trees per acre to 269 trees per acre.

4.4.2 ACREAGE SCENARIO

It has been suggested by people within the apple industry that economies of size exist in orchard production. To the extent that economies of size do exist, the base scenario will be deficient given the difference in the size of the two orchard blocks. A second scenario, acreage scenario, is structured to examine this issue. The objective of the acreage scenario is to eliminate differences resulting from economies of size. For this scenario, the size of B.C.'s orchard block is increased from 20 to 40 acres, while Washington State's orchard block is decreased from 46 to 40 acres. Under these new acreages, the set of capital assets for each region is assumed to remain unchanged. Consultations with orchard specialists in B.C. affirmed that the set of assets defined for a 20 acre orchard block in B.C. can be extended to a 40 acre orchard block. It is felt that the decline in acreage is not enough to warrant a change in capital assets for Washington State. The assumption of no change in capital assets is expected to generate a decline in the per hour ownership cost of B.C.'s machinery. In turn, it will lead to a lower total production cost per acre. The opposite is true for Washington State.

It should be noted that by increasing/decreasing the orchard size, orchards are equated not only in size but also in the proportion of establishment/mature tree ratio in this

scenario. In each case, trees age one through eight constitutes 1.75 acres of the total 40 acres. There are now 26 acres of mature trees. As a result of the new land composition, the average per acre yield of the Washington State's orchard block has been modified (see Table 27). The average per acre yield of the B.C.'s orchard block remains unchanged.

In this scenario, the types of management operations defined for each establishment and mature trees will not change. There is some doubt that the machine hours per operation will decline because land in the Okanagan Valley is divided into parcels of 10 to 11 acres. [25] There is a chance that machine and labour hours may not decrease if the blocks (i.e. two ten acre parcels) being farmed are not located close to each other. Since the general opinions expressed by horticulturists and field representatives indicate that machine labour hours do not change per acre in general, no adjustment is made to any of the management schedules from the base case. The effect on machine hours per operation per acre is assumed to be too minimal to warrant any adjustment for Washington State. Since the set of assets has not changed, a decline in the average opportunity and depreciation cost is expected for the B.C. orchard; fixed costs are being spread over more acres. In Washington State, the reverse, i.e. higher opportunity and

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[25] Increasing an orchard size usually leads to a decrease in machine and labour requirements per acre since time required to adjust and mount an implement can now be spread over more acres.

depreciation cost, is expected since total acreage has declined.

The average per acre cost is $3241 and $4300 for B.C. and Washington State, respectively. For B.C., the results represents a $532 decline over the base scenario. The increase is $102 per acre over the base scenario for Washington State. As expected, these changes result from changes in depreciation and opportunity cost. From a share of 35 percent of total cost, these two costs have declined to 26 percent in B.C. In contrast, the depreciation and opportunity cost in Washington State have increased from 28 percent to 30 percent. On a per pound basis, the average cost has declined by 1.9 cents to 11.7 cents in B.C., but Washington State's cost changes by a very small amount, 0.004 cents.

The redistribution of the share of total average cost in B.C. suggest that the ability of a producer to spread his fixed costs does play a role in determining his total average cost on a per acre and pound basis. The efficiency ratio for B.C. is 0.69, an increase of 17 percent over the base case. From 1.06, the efficiency ratio in Washington State declines by 0.03. The smaller change shown by Washington State is a result of a small decline in total acres.

4.4.3 DENSITY SCENARIO

The orchards defined in the base case differ in planting density. It is reasonable to assume that as density increases, so will labour cost on pruning, harvesting and other related costs, per acre. Consequently, it is considered necessary to examine a scenario in which the density of the orchards are equal. For this scenario, rootstocks, composition of land, capital assets and management practices will remain unchanged from the base case. All costs associated with chemical applications, except fertilizer applied by hand, are considered unchanged. [26] Machine and labour hours required to prune and train trees, thin trees, and the number of bins harvested and handled are adjusted by assuming a constant cost per tree as set out in the management schedules in the base case. This scenario provides an average production cost comparison based on equal density.

Results indicate total average per acre cost increases as tree density increases. The average total cost, in this instance, is $4263 for B.C., an increase of $409 (13 percent) per acre over the base case. Production costs for Washington State will be identical to the base case since no change in density has been made. Material/service cost,

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[26] Discussions with horticulturists indicate that chemical applications are usually recommended on a per acre basis; therefore, no adjustment is required.

labour cost and rent on land are attributed to B.C.'s increase in production cost. A higher rent on land is charged because the average yield per acre has increased 10 percent [27] as a result of more bearing trees in the orchard block. On the other hand, depreciation and opportunity costs' share of total per acre average cost have declined from 35 to 33 percent.

The average total per pound cost has increased from 13.6 cents to 13.8 cents. These results indicate that a 10 percent increase in the average per acre yield is not enough to lower the per pound cost of producing apples when the average per acre cost increases by 13 percent. This suggests that unless the average per acre yield is increased at a rate greater than 10 percent and/or the initial average per acre yield is higher, increasing the density of the trees by 33 percent will not decrease the per pound cost of producing apples in B.C. Alternatively, it suggests that if the average per acre yield is the maximum achievable, then the 202 density is the most efficient system for B.C. The later is doubtful since horticulturists and field representatives in B.C. believe that the per acre average yield employed can be improved.

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[27] Tim Watson, District Agriculturist, B.C.M.A.F., Oliver.

5. CHAPTER V

5.1 SUMMARY AND CONCLUSIONS

The highest total cost per acre by age of trees in B.C. is $5017 (one year old trees). This is follwed by the mature trees with a total per acre cost of $4138. With a differential of $879 per acre, (18 percent of the per acre cost of the one year old trees) these results suggest that the costs associated with keeping the trees in production are less than the costs of replanting the trees. If the income foregone by replanting is added to the total per acre cost, it will increase significantly. This may partly explain why expansion and/or renovation have been retarded in B.C., in the short-run. The decision to replant and/or expand, in the long-run, will depend on the estimated net present value of the investments.

For the six through eight year old trees and mature trees, the total per acre costs are shown to be consistently higher in Washington State than in B.C. The total per acre costs of the mature trees are $4138 and $4753 for B.C. and Washington State, respectively. The lower total per acre cost of $615 in B.C. is a result of lower total per acre labour cost, material/service cost and rent on land. The same categories of costs are responsible for the lower total per acre cost, $523 ($4002 for B.C. and $4525 for Washington

State), for the eight year old trees. Lower rent on land appears to be the prime reason why B.C.'s total per acre cost of the seven year old trees is lower than Washington State's. Lower rent on land, along with lower material/service, repair and maintenance, insurance, property and sales tax, and housing costs in B.C., are responsible for the lower total per acre cost of the six year old trees.

The total per acre cost of the one, four and five year old trees are higher in B.C. than in Washington State. With a respective total per acre cost of $5017 and $4126 for the one year old trees in B.C. and Washington State, the highest cost differential ($891) is obtained. Examinination of the production schedule of the one year old trees revealed that the higher per acre total depreciation and opportunity costs, a total of $762 (85 percent of the total cost differential), are mainly responsible for this large cost differential. A primary explanation for the higher depreciation and opportunity costs in B.C. revolves around the behavioural assumption that apple producers, on the average, will own a rotovator and tree auger in B.C., but not in Washington State. The elimination of the ownership of the tree auger alone can reduce the total cost differential by 23 percent.

The estimated average (average of the individual orchard blocks) total acre costs are $3773 for B.C. and $4198 for Washington State. In B.C., the four highest

categories of cost, in decreasing importance, are material/service, depreciation, labour and opportunity costs. Material/service costs constitute 25 percent of total cost. This is not surprising since this category included input costs such as fertilizers, herbicides, fungicides, nutrients, pesticides, rodenticides, water fees, and custom services. Labour, at 21 percent, holds the third highest share of the average total per acre cost. Depreciation and opportunity costs represent 35 percent of total costs, a relatively high porportion of total costs.

In Washington State, material/service (24.3 percent) and labour cost (24.1 percent) hold the first and second highest share of total average per acre cost. Depreciation and opportunity costs follow with a total of 28 percent. A comparison between the categories in B.C. and Washington State show that a higher proportion of B.C.'s total cost is a result of capital investments. An interesting result to note is that the proportion of total cost resulting from tax and rent on land is higher in Washington State by 3.5 percent.

The average per pound cost is 13.6 and 11.3 cents for B.C. and Washington State, respectively. The 2.3 cents differential translates into a 20 percent higher cost for B.C. producers. This appears inconsistent with the result that the average total per acre cost is lower in B.C. than in Washington State. The explanation lies in the average per acre yields estimated for the two orchards. With a lower

yield by 9119 pounds per acre, B.C.'s per pound cost becomes higher than that of Washington State. The efficiency ratios, based on total output value/total input value, are 0.59 for B.C. and 1.06 for Washington State. These ratios suggest that the Washington State producers are able to obtain higher returns from their expenditures than the B.C. producers.

Exchanging the input prices for the two areas appears to have little effect on the average per acre and per pound cost. In this scenario, the average total per acre cost in B.C. increased from $3773 to $3823, while Washington's per acre cost dropped from $4198 to $4181. The surprising increase in B.C.'s total per acre cost is largely a result of higher rent on orchard land. A lower rent on land is also responsible for the unexpected decline in Washington State's total per acre cost. The per pound cost of producing apples are 13.7 and 11.2 cents for B.C. and Washington State, respectively. If the rents on orchard land are not exchanged, the average per acre cost in B.C. decreases by $105 while Washington State's per acre cost increases by $138. In this case, the per pound cost of producing apples in B.C. is 13.1 cents, a 0.5 cents decrease over the base case. For Washington State, the per pound cost is 11.7 cents, a 0.4 cents increase over the base case.

By increasing B.C.'s orchard block from 20 to 40 acres and holding all management practices and capital assets unchanged, the average total per acre cost is estimated to

decrease from $3773 to $3241, a 14 percent decline. Because the acreage has declined to 40 from 46, the average total per acre cost in Washington State increases from $4198 to $4300, a 2 percent increase. On a per pound basis, both B.C. and Washington State's costs are estimated to be 11.7 cents. For Washington State, the efficiency ratio declines by 0.03 to 1.03. The efficiency ratio increases from 0.59 to 0.69 for B.C. These results indicate that the ability of a producer to spread fixed costs does play an important role in determining costs, especially on a per pound basis.

Results obtained from the density scenario suggest that an increase in density does not necessarily lead to a decline in the per pound costs of producing apples. By increasing B.C.'s density from 202 to 269 trees, the average per acre and per pound cost obtained are $4263 and 13.8 cents. The higher per acre cost is expected since costs associated with harvesting, pruning and training, and various other costs have been increased. However, the higher per pound cost, $0.002 over the base case, is unexpected. An explanation lies in the average per acre yield employed to estimate the per pound cost. With a 33 percent increase in density, the average per acre yield is assumed to increase by 10 percent. With a 13 percent increase in the total average per acre cost, a 10 percent increase in the average per acre yield is not high enough to reduce the average per pound cost of producing apples. No change is observed for Washington State in this instance because no adjustment was

made to the base case.

5.2 LIMITATIONS OF THE STUDY

The use of a "representative" orchard is one alternative method for determining the costs of production. Although this method is considered to be the most appropriate given the availability of data and other factors, caution is required in interpreting the results. The assumed prices, yields and management practices do affect results if changed. For example, the total per acre costs obtained by age of trees, as shown in the production schedules, are specific to the management practices defined. The subtraction or addition of an operation will change the total per acre cost. Furthermore, the assumed machine hours required per operation and the machines used are behavioural assumptions that can alter the costs if changed. As an illustration, if the size of the tractor is increased in B.C., the per hour depreciation and opportunity costs will increase. Ultimately, these changes translate into higher per acre costs.

The average cost per pound is influenced by the average per acre yield employed. For example, by assuming a 10

percent increase in B.C.'s average per acre yield (i.e. 30712 pounds instead of 27920 pounds) the per pound cost decreases to 12.5 cents, as opposed to 13.6 cents. This is a decrease of 1.1 cents per pound; hence, the differential between B.C. and Washington State's costs of production decreases by the same amount.

The efficiency ratios are estimated by using an average market price of 8 and 12 cents per pound for B.C. and Washington State, respectively. These are average prices that do not take into account the quality and grades (i.e. extra fancy,fancy) of the apples produced. A change in the average market prices used will change results. For example, if the average market price in B.C. is assumed to be 9 cents per pound and the average per acre yield remains at 27290 pounds, the efficiency ratio will increase to 0.67 from the current ratio 0.59.

The Canada-US exchange rate (average of 1984) used in this study also plays a role in the overall results. A change in the exchange rate will change all of Washington State's production costs. For example, an increase in the value of the U.S. dollar will generate an increase in the average total per acre and pound costs obtained for Washington State. No change will occur in B.C.'s production costs, assuming the change in the exchange rate does not generate a change in the replacement values of the machines. This may not be a valid assumption since many of the machines purchased in B.C. originate in the U.S.

Consequently, it is suspected that B.C.'s average per acre and pound costs will increase.

Despite the limitations of the results obtained, this study does provide some indication of what the average per acre and pound costs of production are for apple producers in B.C. and Washington State. It provides a comparison between the costs of production in B.C. and Washington State at the farm level. The results have provided some insight as to the economic efficiency (in terms of the producers' ability to obtain returns from expenditures) of B.C.'s apple producers relative to their counterparts in Washington State. Furthermore, by carrying out this exercise, the lack of accurate data has become quite evident. An improvement on current production data would strengthen future cost of production studies.

5.3 FURTHER RESEARCH

A major limitation of this study is that it concentrates on the production (i.e. farm) level. It would be more useful if the industry could be examined as a whole. The results would provide a better insight into the areas within the industry that may differ. The current results

obtained show that the average (average of the individual orchard blocks) per acre cost is lower in B.C. than in Washington State, but on a per pound basis B.C.'s costs are higher. The primary reason lies in the average per acre yield. Consequently, an understanding of why B.C.'s average yield is so much lower than those in Washington State may aid producers in B.C. to achieve lower per pound costs.

In addition, the results show that the B.C. producers are less efficient than their counterparts in Washington State, based on the total output values/total input values ratio. The main explanation evolves around the average market prices. On average, B.C.'s market price is 4 cents per pound less than that of Washington State. With an average market price of 8 cents per pound in B.C., the differential represents 50 percent of its market price. Hence, the question which needs to be asked is why the difference in market prices. Because the prices received by B.C. producers are net of marketing and processing costs, further research into the efficiency of packinghouses is needed.

5.4 POLICY IMPLICATIONS

Recent statements appearing in Country Life and other news media indicate that apple producers have recognized the existence of certain problems within their industry. If the industry is to survive, certain behavioural and structural changes must be undertaken. Through this recognition, certain changes have been implemented or are in the process of being implemented. For example, incentives for improving the quality of the fruit being shipped to the packinghouses have been implemented through a pricing mechanism. The previous central marketing system has been modified to allow independent marketing by individual packinghouses. The possible adoption of new apple varieties is being considered. High density systems are becoming increasinly recognized as a means to future survival for this industry.

What role should the government play in relation to this industry? Results indicate that low average per acre yields and producer prices are two main reasons why B.C. apple producers are less efficient in obtaining returns from their expenditures than their counterparts in Washington State. For policy purposes, these are two areas that the government may want to consider.

According to horticulturists and field representatives in B.C., the per acre yields in B.C. are disadvantaged relative to Washington State by climate and soil. Unlike

climate, an uncontrollable factor, soil conditions can be improved if managed properly. Consequently, more research could be undertaken to determine methods that apple producers could employ to improve their soil. Improvement could come both in terms of soil fertility and alleviating the effects of apple replant disease.

In Europe, high density systems have been adopted to increase yields, especially during the establishment years. Currently, research has been undertaken to determine the appropriate high density system (i.e. variety of rootstock and spacing) for B.C. However, the skills required to manage a high density system differ from those of a low density system. Unless the skills required to manage a high density system are acquired, higher yields may not be achieved. To aid the adoption of the high density systems in B.C., the government could organize workshops to provide information on the management of these systems.

Since market prices are largely determined exogenously, the government could do little to influence it, except for direct price support programs. However, other forms of assistance may be preferable to price support programs. An example is the improvement of the storage system in B.C. By providing assistance to improve the storage system, it will allow producers to sell more during the off-season when market prices are usually higher.

8. BIBLIOGRAPHY

Agriculture Canada. "Apple Market Review." Marketing and Economics Branch, Agriculture Canada, 1984.

Agriculture Canada. "Government Assistance To The Tree Fruit Industry For Land Development And Irrigation Projects in B.C. and Washington State." Regional Development Branch, Agriculture Canada, March 1984a.

Agriculture Canada. "Impact of Taxation Provisions on Orchard Establishment, Expansion and Renovation in B.C." Regional Development Branch, Agriculture Canada, March 1984b.

American Society of Agricultural Engineers. Agricultural Engineers Yearbook. St. Joseph, Missouri, 1983.

Andison, Allan; Kennedy, George; and Graham, John. "Historic Production Data For Specific Apply Orchard Systems in the Okanagan Valley of B.C." Economics Branch, Agriculture Canada, September 1977.

B.C. Ministry of Agriculture and Food. "1983 Farm and Food Statistics." B.C. Ministry of Agriculture and Food, April 1984.

B.C. Ministry of Agriculture and Food. "Estimated Costs and Returns: Apple Orchard Establishment and Production." B.C.M.A.F., Economics Branch, May 1982.

B.C. Ministry of Agriculture and Food. "Estimated Costs and Returns: Apple Orchard Establishment and Production." B.C.M.A.F., Economics Branch, May 1984, 1982.

Cahill, Sean. "Apple Production In The Pacific Northwest: A Comparative Study." B. Sc. Thesis, Department of Agricultural Economics, University of British Columbia, 1982.

Campbell, Elizabeth M. "A Study of Canada's Apply Industry." Marketing and Economics Branch, Agriculture Canada, 1983.

Doll, J. P. and Orazem, F. Production Economics Theory With Applications. 2d ed. New York: John Wiley and Sons, 1984.

Dawson, Dau and Associates Limited. "B.C. Tree Fruit Orchard Condition." March 11, 1984.

Graham, John D.; Kennedy, George; Marshall Allan A. "A Multi-Period Orchard Management Model." Economics Branch, Agriculture Canada, November 1977

Harrington, David H. "Costs and Returns; Economic and Accounting Concepts." Agricultural Economics Research, 35:4 (October 1983): 1-8.

Hinman, H.R.; Hunter, R.E.; and Tukey, R.B. "1985 cost of Establishing An Apple Orchard Columbia Basin, Washington." Cooperative Extension, College of Agriculture, Farm Business Management Reports, January 1985.

Hinman, H. R.; Tukey, R.B.; and Hunter, R.E. "Estimated Cost of Production for a Red Delicious Apple Orchard in Central Washington." Cooperative Extension, College of Agriculture, Farm Business Management Reports, June 1982.

Hinman, H.R.; Tukey, R.B.; Hunter, R.E.; and Willet, G.S. "1981 Cost of Establishing An Apple Orchard, Columbia Basin, Central Washington." Cooperative Extension, College of Agriculture, Farm Business Management Reports, September 1981.

Hoffman, George, and Gustafson, Cole. "A New Approach To Estimating Agricultural Costs of Production." Agricultural Economics Research, 35:4 (October 1983): 9-14.

Hudson, S.C. "An Economic Study of the Tree Fruit Industry in British Columbia." B.C.M.A.F., September 1973.

Jenkins, Glenn P. "Capital in Canada: Its Social and Private Performance 1965-1974." Economic Council of Canada, October 1977.

Kennedy, George. "B.C. Tree Fruit Industry: Some Economic Considerations." Paper presented to Agriculture Canada Horticultural Review, Kelowna B.C., 30 September 1980.

McNeill, Roger G. "Production Functions For Apple Orchard Systems In The Okanagan Valley Of British Columbia." M.Sc. Thesis, Department of Agricultural Economics, University of British Columbia, November 1977.

Noonan, Ted. "Orchard Industry Basis of Okanagan Economy." Country Life, June 1983:

Noonon, Ted. "Whelan Meets Fruitgrowers Has No Answer to Distress." Country Life, November 1983: A1.

O'Rourke, A. Desmond. "The Future Size of the Washington Apple Crop." Provisional Impact Centre Working Paper 1. College of Agriculture and Home Economics, Washington State University, Pullman, Washington, 1984.

Schotzko, Tom. "What Is The Future of The Apple Industry?" Paper presented at the 47th Annual Horticultural and Traffic Association Okanogan meeting, 4 February 1982.

Short, Cameron and McNeil, Roger. "Tractor Costs and Canadian Tax Policy." U.B.C. Discussion Paper, 1985.

Swales, Ted. "Swales Shares Ideas On Future for Delicious." Country Life, March 1984: A9.

Swales, Ted. "Swales Shares More Ideas On Future of Red Delicious." Country Life, April 1984: A11.

Watts, Myles J. "Machinery Repair Functions and Depreciation." North Central Journal of Agricultural Economics, 4(1982):69-72.

Watts, Myles J. and Helmers, Glen A. "Machinery Costs and Inflation." Western Journal of Agricultural Economics, 6(1981):129-45.

United States Department of Agriculture. "Estimating Agricultural Costs of Production-Workshop Proceedings." Economics, Statistics, and Cooperative Services, June

APPENDIX A

TABLE A1

COMPARING PRODUCTION COSTS: B.C. VS WASHINGTON STATE, IN 1984 CANADIAN DOLLARS

	AVERAGE COST PER HECTARE				AVERAGE COST PER KILOGRAM	
	B.C. ($)	(%)	WASH. ($)	(%)	B.C. ($)	WASH. ($)
DEPRECIATION	2063	22.1	1856	17.9	0.066	0.044
OPPORTUNITY	1221	13.1	1100	10.6	0.040	0.026
INS, PROP, SALES	539	5.8	754	7.3	0.018	0.018
REPAIR & MAINTENANCE	168	1.8	215	2.1	0.004	0.004
FUEL & LUBRICANT	40	0.5	5	0.1	0.002	0.000
LABOUR	1974	21.2	2496	24.1	0.064	0.060
MATERIAL/SERVICE	2362	25.3	2518	24.3	0.075	0.062
TAX & RENT ON LAND	457	4.9	882	8.5	0.015	0.022
OVERHEAD & INT. ON OPERATING COST	499	5.4	549	5.3	0.015	0.013
TOTAL COST PER ACRE	9323	100.0	10373	100.0	0.300	0.250

APPENDIX A

TABLE A2

PRODUCTION COSTS PER HECTARE: B.C. VS WASHINGTON STATE, IN 1984 CANADIAN DOLLARS

	BASE CASE		SCENARIOS INPUT PRICE[a] (CASE 1)		ACREAGE[b] (CASE 2)		DENSITY[c] (CASE 3)	
	B.C.	WASH.	B.C.	WASH.	B.C.	WASH.	B.C.	WASH.
DEPRECIATION COST	2063	1856	2063	1856	1238	1992	2177	1856
	22.1	17.9	21.8	18.0	15.5	18.7	20.6	17.9
OPPORTUNITY COST	1221	1100	1221	1100	813	1181	1268	1100
	13.1	10.6	12.9	10.6	10.2	11.1	12.0	10.6
INS, PROP, SALES & HOUSING	539	754	539	754	465	820	576	754
	5.8	7.3	5.7	7.3	5.8	7.7	5.5	7.3
REPAIR & MAINTENANCE	168	215	168	215	178	193	180	215
	1.8	2.1	1.8	2.1	2.2	1.8	1.7	2.1
FUEL & LUBRICANT	40	5	17	7	20	7	40	5
	0.5	0.1	0.2	0.1	0.2	0.1	0.4	0.1
LABOUR COST	1974	2496	1742	2827	1974	2491	2234	2496
	21.2	24.1	18.4	27.4	24.7	23.4	21.2	24.1
MATERIAL/SERVICE	2362	2518	2345	2530	2365	2515	2844	2518
	25.3	24.3	24.8	24.5	29.5	23.7	27.0	24.3
TAX & RENT ON LAND	457	882	882	457	457	880	633	882
	4.9	8.5	9.3	4.4	5.7	8.3	6.0	8.5
OVERHEAD & INT. ON OPERATING COST	499	549	469	586	499	546	583	549
	5.4	5.3	5.0	5.7	6.2	5.1	5.5	5.3
TOTAL AVERAGE COST	9323	10373	9447	10331	8008	10625	10534	10373
TOTAL PERCENT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[a] Land tax and rent, labour, water fee, fuel, and tree prices in B.C. are equated to Washington State.
The same procedure is applied to the orchard in Washington State.

[b] B.C. and Washington's orchard blocks have been increased/decreased to 40 acres.

[c] Density of B.C.'s orchard has been increased from 202 trees per acre to 269 trees per acre.

APPENDIX A

TABLE A3

PRODUCTION COSTS PER KILOGRAM: B.C. VS WASHINGTON STATE, IN 1984 CANADIAN DOLLARS

	BASE CASE		SCENARIOS INPUT PRICE[a] (CASE 1)		ACREAGE[b] (CASE 2)		DENSITY[c] (CASE 3)	
	B.C.	WASH.	B.C.	WASH.	B.C.	WASH.	B.C.	WASH.
DEPRECIATION COST	0.066	0.044	0.066	0.044	0.040	0.049	0.064	0.044
	22.1	17.9	21.8	18.0	15.5	18.7	20.6	17.9
OPPORTUNITY COST	0.040	0.026	0.040	0.026	0.026	0.029	0.037	0.026
	13.1	10.6	12.9	10.6	10.2	11.1	12.0	10.6
INS, PROP, SALES & HOUSING	0.018	0.018	0.018	0.018	0.015	0.020	0.018	0.018
	5.8	7.3	5.7	7.3	5.8	7.7	5.5	7.3
REPAIR & MAINTENANCE	0.004	0.004	0.004	0.004	0.007	0.004	0.004	0.004
	1.8	2.1	1.8	2.1	2.2	1.8	1.7	2.1
FUEL & LUBRICANT	0.002	0.000	0.001	0.001	0.001	0.001	0.001	0.000
	0.5	0.1	0.2	0.1	0.2	0.1	0.4	0.1
LABOUR COST	0.064	0.060	0.055	0.068	0.064	0.060	0.064	0.060
	21.2	24.1	18.4	27.4	24.7	23.4	21.2	24.1
MATERIAL/SERVICE	0.075	0.062	0.075	0.062	0.075	0.062	0.082	0.062
	25.3	24.3	24.8	24.5	29.5	23.7	27.0	24.3
TAX & RENT ON LAND	0.015	0.022	0.029	0.011	0.015	0.022	0.018	0.022
	4.9	8.5	9.3	4.4	5.7	8.3	6.0	8.5
OVERHEAD & INT. ON OPERATING COST	0.015	0.013	0.015	0.013	0.015	0.013	0.018	0.013
	5.4	5.3	5.0	5.7	6.2	5.1	5.5	5.3
TOTAL AVERAGE COST	0.300	0.250	0.303	0.248	0.259	0.259	0.306	0.250
TOTAL PERCENT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[a] Land tax and rent, labour, water fee, fuel, and tree prices in B.C. are equated to Washington State.
The same procedure is applied to the orchard in Washington State.

[b] B.C. and Washington State's orchard blocks have been increased/decreased to 40 acres.

[c] Density of B.C.'s orchard has been increased from 202 trees per acre to 269 trees per acre.

7. APPENDIX B

LIST OF VARIABLES

VARIABLE	DEFINITION
SV_i (t)	Annual salvage or remaining value of machine i at time t
$RFV1_i$	first salvage factor for machine i
$RFV2_i$	second salvage factor for machine i
RV_i	replacement value of machine i
T	life of machine (replacement age) in years
D_i	annual depreciation cost of machine i
r	discount rate
a(r,T)	annualization factor as a function of life T and discount rate r
OC_i	annual opportunity cost of machine i
I_i	annual insurance cost of machine i
P_i	annual property taxes of machine i
S_i	annual sales tax of machine i
O_i	annual housing cost of machine i

$R\&M_i$ (t)	annual repair and maintenance cost of machine i
CRC_i (H)	cumulative repair and maintenance cost as a function of cumulative hours of use H
H	cumulative hours of use
h_i	annual hours used of machine i
$RF1_i$	accumulated repair constant
$RF2_i$, $RF3_i$	repair constants that combine to determine the shape of the repair rate curve
$F1_i$	annual fuel cost (tractor)
$F2_i$	annual fuel cost (pickup)
hp	number of horsepower
m	fuel consumption multiplier
f	per unit cost of fuel
L_i	annual lubricant cost of machine i
IC	interest on operating capital
σ	total per acre operating cost
d	nominal interest rate
AC	per acre average total production cost

C(g)	total per acre cost as a function of age g of trees
b(g)	number of acres planted as a function of age g of trees
B	total number of acres in orchard block
y(g)	average yield per acre as a function of age of trees, g

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